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U.S. Essential Air Services Study

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U.S. ESSENTIAL AIR SERVICES STUDY

by

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FOREWORD

The passage of the U.S. Airline Deregulation Act (ADA) in 1978 changed substantially many aspects of the U.S. airline industry. One area in which the Act placed a firm emphasis concerned air service to small communities. The Essential Air Services Program (EAS) was established under section 419 of the Federal Aviation Act, as amended by the ADA, whereby the continuity of air service to small communities is guaranteed during the transition to a fully deregulated environment. Since the EAS program has been in effect for six years and since it has completely replaced the local service subsidy program, it is an opportune time to examine its effects.

This report highlights key aspects of the U.S. air deregulation legislation and the EAS program as well as presents an analysis as to their impact on small communities. In the Canadian case, the continuation of small community air service is guaranteed by maintaining the regulatory regime in northern and remote areas, as described under the domestic air liberalization policy announced by the then Minister of Transport on May 10, 1984. Should such a policy be modified to reflect the relaxation of government intervention, it is anticipated that certain valuable insights from the U.S. experience in dealing with the EAS program may be realized which will be relevant to analogous situations in Canada's northern and remote areas.

The Research Branch of the Canadian Transport Commission, in making this study available to the public, does so in order to promote discussion and knowledge of transportation issues. Nevertheless, the opinions expressed do not necessarily reflect the views of the Commission.

Yves Dubé
Vice-President (Research)

Canada

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Chapter 1

INTRODUCTION

The signing of the Airline Deregulation Act (ADA) by President Carter on October 24, 1978 signalled the end of 40 years of airline regulation in the United States. The legislation has substantially changed many aspects of the U.S. airline industry. One of the focal points of the Act concerns air service to small communities. The ADA places a firm emphasis on small community service, recognizing the need for an integrated air transportation system that is easily accessible by all travellers in the U.S.

The subsequent discussion provides an outline of U.S. air deregulation and its effect on small communities. Chapter 2 presents a brief historical background of airline deregulation as well as arguments for and against airline deregulation, and lists the major provisions of the ADA. Chapter 3 examines air service to small communities prior to the ADA, as well as globally describing the subsidy programs under sections 406 and 419. Chapter 4 presents an analysis of the effects of deregulation on small communities. Included in this overview are the criteria for defining small communities, the methods used in determining subsidy payments, and some preliminary estimates as to the impact of the subsidy program. The final chapter examines the implications of the U.S. experience for Canada.

The study was undertaken because, as was apparent from the recent review of adequacy of air service in northern and remote areas of Canada[1], the federal government should play an active role in maintaining, improving, and monitoring the quality of air services in the "regulated" zone, and that a more competitive operating environment should be incorporated, when appropriate. In compliance with these requirements, due consideration must be given to designing a program in which incentives for the efficient operation of air services are included. In this regard, certain experiences of the U.S. Essential Air Services program are valuable.

Chapter 2

AIRLINE DEREGULATION

2.1 Historical Perspective

Airline passenger regulation had its formal origins with the 1938 Civil Aeronautics Act which authorized the creation of the Civil Aeronautics Authority, later renamed the Civil Aeronautics Board (CAB). Prior to then, only airmail carriers had been subject to regulation. The 1938 Act formed the basis for a comprehensive system of regulation, as well as a detailed set of safety controls for the U.S. airline industry. The desire for government intervention arose as a result of the economic climate prevalent during the Depression and as a response to the perception of excessive, cut-throat competition within the airline industry which was viewed as contributing to the instability of the industry and as influencing its subsequent development.

The 1938 legislation vested the regulatory agency with several broad powers including the authority to regulate fares, control market entry/exit, and to administer subsidy payments. The major elements of airline regulation remained essentially the same until 1976 when the process of deregulation commenced with the exception of the transfer, in 1958, of safety matters by virtue of the Federal Aviation Act to the Federal Aviation Administration. Needless to say, the CAB continued under the 1958 Act to exercise its broad legislative and regulatory functions.

For at least 20 years before deregulation, various administrations had sought to eliminate burdensome regulation. The genesis of the ADA can be traced back to early 1975 in the Economic Report of the President[2], followed by open hearings in February 1975 on the "Oversight of Civil Aeronautics Board Practices and Procedures" and the issuance of "Civil Aeronautics Board Practices and Procedures" by the Subcommittee on Administrative Practice and Procedures. All the findings were in favour of more open entry and greater fare-setting flexibility. In early March 1977, President Carter sent a message to Congress urging them to pass the ADA. The Senate hearings were held during March and April of 1977 and views on both sides were presented.

2.2 The Debate of Regulation vs. Deregulation

The regulation of U.S. airlines had long been criticized as unnecessary and as contributing to inefficiency. Conversely, many felt that deregulation would result in serious operating and financial instability for the airlines and would reduce the variety and quality of service offered. Both the proponents and the opponents of airline deregulation claimed support for their positions in the experiences before and since deregulation based on the following arguments:

2.2.1 Arguments in Favour of Airline Deregulation

The following arguments represent the views which promoted airline deregulation:

1. It was suggested that regulation had fostered poor economic growth and promoted inefficiency (e.g. imposition of inefficient operating standards on new entrants to the market, and awarding of new routes to weak carriers).

2. The CAB was viewed as overly paternalistic and protective. In terms of market entry, the CAB has shown a reluctance to certificate any new trunk carriers and a resistance to carriers expanding into new markets. By restricting the degree of competition, it was argued that regulation had led to excessive costs, inadequate service, and excess investment within the industry.

3. It was stated that the CAB controlled the industry too tightly and left airline management very little discretion. The CAB was criticized for its excessive rigidity, legal formalism, bureaucratic delay, and its aversion to risk.

4. It was believed that regulation created incentives for airlines to provide more expensive air service than travellers demanded (i.e. a quality of service which was higher than many passengers thought they needed). Deregulation would result in increased competition (in terms of price and service) and thereby streamline the industry and reduce air fares.

5. Regulation was seen as resulting in a fare structure which provided a limited choice of fares. The competition associated with deregulation would result in lower fares which would induce more passengers to travel (e.g. higher load factors and less generous wage settlements were associated with airline deregulation).

6. Employment was expected to increase as the industry became more flexible and dynamic, providing new opportunities for expansion and development.

2.2.2 Arguments Against Airline Deregulation

Four basic arguments were put forward to continue airline regulation:

1. It was noted that regulation helped curb increases in the level of rates. From 1948 to 1977, rates in the airline industry rose less than in other industries.

2. Another defense against deregulation was that deregulation would have a detrimental effect on employment in the industry.

3. It was believed that deregulation would lead to cut-throat and destructive competition leading to widespread monopoly power and precipitating a significant shake-out of the industry (i.e. bankruptcy of some carriers and the merger of others). The results were expected to benefit the large carriers and hurt the smaller ones.

4. Deregulation was expected to have a detrimental effect on small communities. In order to maintain an adequate level of service at these communities, the level of subsidies would have to increase significantly.

The process toward deregulation of the airline industry since the Airline Deregulation Act has precipitated many fundamental changes. From an economic standpoint, the most significant effects were with respect to pricing, market entry, and market exit.

The statutory timetable established in the ADA for deregulation of pricing, market entry, and exit was as follows:

1. Domestic fare deregulation was scheduled to become effective on January 1, 1983;

2. Regulations concerning market entry were to be completely terminated on December 31, 1981; and

3. Regulations in respect of market exit are scheduled to be terminated concurrently with the Essential Air Services Program on October 24, 1988.

Prior to the implementation of the deregulation schedule, the Act had put forward principal guidelines so that

greater flexibility in the regulatory framework would be ensured during a period of transition. In fulfilling the goals and timetable specified in the ADA, the Board modified its policies on domestic fares and on procedural regulations. Appendix A demonstrates the gradual easing of regulation during the transition period as specified under provisions of the Act, together with rulings adopted by the Board. The move towards deregulation with respect to pricing, market entry, and market exit is described hereafter.

2.3 Pricing

From the origin of the CAB (1938) to the mid-1970s, the U.S. airline industry experienced a gradual evolution from a state in which regulation concentrated on individual airline's financial needs to a state in which regulation of tariffs was based on general industry cost characteristics. By 1976, the trend toward less regulation was evident with significant departures from the historically restrictive regulatory practices of the CAB. This was particularly the case with respect to airline pricing, where the CAB reversed its previous policy of disallowing discount fares by agreeing in principle to certain discount fares, an attitude which continued to broaden over the next two years.

In exercising its authority over pricing matters, the CAB had controlled both the standard and the discount fares. As a result of this regulation, price competition was inhibited and airlines concentrated on achieving high rates of return. The resulting emphasis on non-price competition encouraged airlines to offer more capacity than markets may have warranted, as is evidenced by the decline in load factors through most of the 1950s and 1960s. This imbalance between fares and costs continued through the mid-1960s with the switch to jet aircraft and the downturn in travel demand. Responding to a request from Congress, the CAB initiated a General Passenger Fare Investigation (GPFI) (1956-1960). The GPFI reiterated the need for a reasonable return on investment for the industry and suggested that fares be brought into line with costs. With a view to realizing these objectives, in 1969, the Board approved rate increases in markets under 1 800 miles, and adopted a new fare structure based on a distance fare formula. Nevertheless, at this time the Board failed to establish standards by which fare increases could be systematically judged. Subsequently, as a result of a court ruling, the Board was forced to suspend the proposed fare increases and to initiate a formal investigation, the Domestic Passenger Fare Investigation (DPFI) (1970-1974).

Following the DPFI, the Board adopted regulations aimed at encouraging greater efficiency and at relating fares more closely to the costs of service. The Board also established standards in terms of load factors, seating density standards, target debt/equity ratios, and rates of return. However, the

DPFI failed to distinguish between markets of different densities. In addition, fare levels in the short-haul markets were deliberately set below their corresponding costs. Moreover, the Board maintained that discount fares were not justified and put strict limits on their use. Nevertheless, the DPFI exposed the shortcomings of the then existing regulatory system with respect to pricing.

Recognizing the weakness and limitations entailed in the policies developed by the DPFI, the Board adopted a new policy under Policy Statement 80 (PS-80) in August 1978. Under the new rules, carriers were no longer required to file identical fares for all markets of equal distance, and all pricing constraints on first-class fares were removed. Henceforth, fares were allowed to move within a specified range known as a non-suspension zone without likelihood of suspension. With reference to a move to the suspension zone, certificated carriers were allowed, without providing justification to the Board, to establish fares ranging up to 5% or 10% above the ceiling fares. In markets where four or more carriers had non-stop authority, the upper limit was 10% above the ceiling fares; in all other markets, the upper limit was 5%. The downward limit of the zone of flexibility was generally 50% below the ceiling fare, or 70% below the ceiling fare for up to 40% of a carrier's weekly capacity. The new policy provided carriers the flexibility to engage in fare competition, on a market basis, relatively free from government intervention.

A non-suspension zone, similar to that established under PS-80, was statutorily defined under the ADA.[3] Moreover, guidelines underlining a transition from a regulated to a fully deregulated environment were established under provisions of the Act. For example, other than the State of Alaska, the authority of the individual states to regulate intrastate fares, routes, and services was pre-empted, thereby entrusting, in whole, the regulatory jurisdiction to the Board.[4] In addition, a Standard Industry Fare Level (SIFL) was introduced. The SIFL, from which the zone of flexibility was calculated, was initially set at the fare levels in effect as of July 1, 1977. The Board was required to adjust the SIFL, not less than semi-annually, by a percentage which corresponded to changes in the actual operating costs per available seat-mile in the previous periods.[5]

In accordance with section 1002(d)(7) of the Federal Aviation Act (FAA) as amended by the ADA, the Board was authorized to widen the statutory zone of reasonableness for downward price movements. For the purpose of providing carriers greater latitude in pricing during a transition period, the Board subsequently exercised its authority to vary the statutory zone of flexibility downwards[6] as well as upwards.[7] In 1980, full downward flexibility was incorporated into all markets and full upward flexibility was allowed for short-haul markets. Finally, on January 1, 1983, in accordance with section 1601(a)(2) of the

amended FAA, the Board's authority to regulate domestic fares ended. Now, we can proceed to describe the move towards deregulation of market entry.

2.4 Market Entry

Under regulation, market entry was highly restricted in that an airline operating an interstate route was required to hold a CAB certificate listing the routes it was authorized to serve. In 1938, the 16 airlines then existing were certificated ('grandfathered') and became known as the trunk carriers. Potential entrants to markets were required to be certificated providing that they were "fit, willing and able" to provide service. During the 40 years of route regulation, the Board did not approve a single application for entry. The only significant entrant to scheduled service came in 1944 when the CAB announced its local and feeder service policy. Initially, the locals were certificated only to replace trunk carriers in providing subsidized service to small communities, although eventually they were allowed to serve major markets. The first applicants chosen for local air service markets were granted only temporary certificates and the first permanent certificates were not issued until 1955. (This policy with respect to market entry remained virtually unchanged until the 1978 Airline Deregulation Act.)

In 1970, the CAB adopted a "route moratorium" which continued for approximately seven years. During this time, the Board ceased processing applications for new routes and did not authorize any new competitive city pair routes for domestic carriers. The CAB, in 1971, also authorized capacity agreements, which involved a series of meetings between airlines so as to limit capacity on 13 major long-haul routes with substantial excess capacity.

Under the provisions of the ADA, the Board's authority in respect of route regulation was to be terminated as of December 31, 1981.[8] Prior to expiry of the said authority, increased flexibility in route regulation was incorporated into the ADA. Firstly, an Automatic Market Entry (AME) program was established under section 40(d)(7)(A), whereby existing carriers were allowed to enter into one non-stop route each year during the transition period without the Board's approval.[9] Protection was also established for existing markets in that an incumbent carrier could prevent any other carrier from obtaining AME authority to serve one of its routes by filing a notice to the Board on the first day of the year. However, the protection was only limited to one city pair per carrier per year.[10] The Act also specified that the AME program should be modified, on an emergency basis, if the Board determined that the program's operation was causing substantial harm to the national air transportation system where such harm could only be alleviated by means of modifications.[11]

Secondly, carriers were allowed to obtain authority on a non-stop route which was considered to be unused or dormant, and defined as one where the incumbent carrier(s) failed to provide at least five round trips per week for a minimum of 13 consecutive weeks during a 26-week period. For markets where the only certificated incumbent carrier had failed to meet at least the minimum level of service, the Board was required to authorize the service within 15 days to the first applicant, provided that there was compliance with FAA regulations and conformity with the Board's regulations.[12]

The most important change was the shift in the burden of proof in connection with route authority applications. Before the enactment of the ADA, a carrier applying for route authority was required to demonstrate that such entry was consistent with public convenience and necessity. Under section 401(d)(9)(B) of the amended FAA, carriers opposed to such an application would have the burden of showing that such entry was contrary to public convenience and necessity. In addition, sections 401(c)(3) and 401(P) of the Act specified that the Board was required, no later than 180 days after the passage of the Act, to promulgate rules establishing expedited or simplified procedures to process applications. As a consequence, domestic route authority was awarded to all fit carriers, and for a period of almost three years prior to the relinquishing of the Board's route authority, considerable flexibility had already been provided for the carriers in establishing their own network configurations. Finally, we will review the move towards deregulation of market exit.

2.5 Market Exit

Fearing that deregulation might deprive small communities of their essential air services, restrictions on market exit continue to be in effect until the expiry of the Essential Air Services (EAS) Program in October 1988. Before the passage of the ADA, certificated carriers were required to obtain specific Board approval before termination or suspension of service to any point listed on their certificates. Under section 401(J) of the amended FAA, the pre-termination approval was eliminated, and it was replaced with a notice-filing requirement. Should any carrier wish to terminate, suspend, or reduce its service to a community below the minimum required level which the Board (and as of January 1, 1985, the Department of Transport)[13] deemed essential, the carrier was required to file a notice with the Board, the affected community and the state agency at least 90 days before the proposed change in service. If, at the end of such a 90-day period, the Board was not able to find another air carrier to provide EAS to such a point, the incumbent carrier had to maintain such service, on a 30-day "hold-in" basis, until the community's EAS requirements could be met.[14]

The carrier would, in turn, be compensated for any losses that it had incurred in complying with the "hold-in" provision. With the exception of trunk carriers for which the "hold-in" compensation was limited to a maximum of one year, the "hold-in" compensation could be renewed every 30 days until the expiry of the EAS program in 1988.[15]

Chapter 3

EFFECTS OF DEREGULATION ON SMALL COMMUNITIES

3.1 Historical Perspective

The problem of inadequate levels of air service to small communities had been one of the Board's major concerns since the early 1940s. In the late 1940s, the Board instituted the local service experiment to relieve the trunk carriers of their responsibility to provide subsidized service to small communities. The program[16] was designed to provide air service to low-density markets which the trunk carriers had largely neglected and from which they sought to withdraw. Prior to that time, no airline was allowed entry if it would compete with any part of the established trunk system. The first applicants for the local air service were granted only temporary certificates on an experimental basis. In 1955, permanent certificates were granted to 14 local service airlines, which by then were receiving almost all of the federal subsidies for small community passenger and mail service. Certificates were also issued to a few small commuter carriers so that they could receive federal subsidies as well.

Initially, service under this program was comprised mainly of small aircraft operations serving small communities. As the local service carrier operations grew over time, larger aircraft were acquired in the early 1950s with the objective of serving longer-haul and more dense markets. Subsequently, the Board granted approval for the locals to enter into these markets so as to reduce the amount of subsidy. Since the same aircraft were also used to serve small communities, the amount of local service subsidies increased. At the same time, the local carriers sought to terminate service at numerous small communities where service was generally less lucrative.

In accordance with the Board's "use-it-or-lose-it" policy, 11 communities lost service between 1964 and 1966 (although between 1967 and 1970, commuter carriers replaced locals at 31 points). In the 10 years prior to the passage of the ADA, the Board deleted 127 points from the carriers' certificates after concluding that the cost to the government and carriers involved did not justify the continuation of service. Among these 127 communities, some were able to regain air service through commuter carriers, but most were left without any service.

By the early 1970s, it became clear that the local service subsidy program, authorized under section 406 of the Federal Aviation Act (FAA), had failed to maintain an adequate level of air service to small communities. The total subsidy costs were growing, despite a decline in the level and quality of service at small communities. Furthermore, many communities that generated sufficient traffic to become subsidy-free, were included in the program.

Recognizing the problems inherent in the section 406 subsidy program, the Board initiated a proposal in 1972 which sought to base the subsidies on a low-bid contracting system. In addition to reducing subsidy costs, this move was aimed at ensuring that the Board had greater control over airline efficiency and quality of service. The proposal was not adopted until a similar program was incorporated into section 419 (the Essential Air Services Program) of the FAA, as amended by the ADA.

The Essential Air Services (EAS) Program ensured that those small communities which received certificated service before the ADA would continue to have service for at least ten years. It also allowed the Board to evaluate each community based on a minimum level of service required. The effects of the EAS are basically of three types:

(a) It has prevented small communities from losing all of their air service as a result of the airlines' new freedom to respond to the demands of the market;

(b) It has reduced the amount of subsidy required to support small community air service by at least one-third, or $25 million, by effectively guaranteeing only the minimum level of required service and by increasing the competitive pressure in the non-hub markets; and

(c) It has provided airlines with the incentive to restructure their route systems in an orderly and efficient manner, and to adjust their capacity to reflect the level of market demand.

3.2 Section 406 vs. 419 Subsidy Programs

This section provides some insight into the differences between the section 406 and section 419 subsidy programs.

3.2.1 Section 406 Subsidy Program

The 1978 Airline Deregulation Act significantly amended section 406 of the 1958 FAA. Until section 419 was fully implemented, the ADA required that subsidization under section

406 be sufficient to enable the provision of service of "the same extent, character and quality as was provided prior to the Act".

Historically, subsidies to local service and regional carriers had climbed steadily since World War II, albeit with a short period of decline in the late 1960s. The subsidy program was originally designed as a compensatory system for the carriage of mail, and the subsidies were authorized under section 406 of the FAA and its predecessors. Since the early 1960s, the subsidy had been paid according to a series of class rates or rate formulas for determining the level of subsidy a carrier should receive. Although the conditions differed for each class rate, in general the rates were determined with reference to:

1. the number of days each eligible point was served;
2. the number of departures from each eligible point; and
3. the number of plane-miles flown in providing the subsidized service.

The preceding was subsequently adjusted downward to reflect the number of revenue-passengers and revenue passenger-miles generated throughout the carrier's system.

The subsidy program under section 406 provided an incentive to use jet aircraft which were ill-suited to the needs of small communities. Furthermore, the subsidy did not vary by the time of day the flight was provided nor by the number of stops. Consequently, by scheduling flights at inconvenient times and by flying multi-stop routes among subsidy-eligible points, carriers could receive a higher level of compensation.

In October 1979, the Board adopted Class Rate IX (retroactive to July 1978) which incorporated refinements in the rate-making procedures and established a service incentive payment for temporarily maintaining services by the subsidized local carriers. The Board recognized that 'normal' profits incorporated in the basic subsidy would not necessarily induce continued service at small communities, and consequently, it added a service incentive payment.

3.2.2 Section 419 Subsidy Program

As was stated, previously the ADA has served to facilitate and promote competition in the domestic air transportation system by reducing the regulatory barriers to entry, exit, route authorization, and fare restrictions. For fear that such increased flexibility might lead to substantial reduction or termination of air service to small communities, an Essential Air Services (EAS) Program was established under section 419 of the Act to guarantee a continuation of domestic small community service during the transition from a regulated to a deregulated environment. The original terms of the ADA

specified the transition from the local service program to the EAS program in which the latter would be fully operational as of September 30, 1982. Appendix B illustrates the principal events of deregulation concerning the EAS program.

The general principle underlying the ADA was that the public would benefit from allowing carriers to alter their operations in response to market demand. Section 419 was included as an exception tc the principle in recognition that total reliance on market forces may not always be attainable in the case of small communities.

According to section 419 of the Act, the Board (DOT) is required to compensate air carriers for the provision of essential air service in two types of situations:

1. where the Board (DOT) requires an incumbent carrier to maintain the minimum required level of service to an eligible point for 30-day periods beyond the date for which the carrier has applied for suspension or reduction of service; and

2. whenever a replacement carrier providing the service to an eligible point on an unsubsidized basis cannot be found.

In the first case, the incumbent carrier is to be compensated under a "hold-in" rate which can either be the existing subsidy if the carrier has been receiving a subsidy for the service, or compensation for losses incurred by the carrier if the service is not subsidized. In the second situation, a willing and qualified carrier will be selected to provide the service to an eligible point with the section 419 subsidies based on the EAS level established by the Board.

Two significant provisions of the Airline Deregulation Act are that essential air service was no longer required to be provided by jet aircraft, and that commuter carriers were eligible for subsidization under section 419. The rationale behind the first provision was that small turboprop commuter aircraft were expected to operate more efficiently in low-density short-haul markets typical of subsidy-eligible points. The inclusion of commuter carriers in providing essential air service made situations possible in which a subsidized local service carrier would terminate service to a point and a commuter could offer replacement service with subsidization, if so warranted.

Chapter 4

ANALYSIS OF THE U.S. ESSENTIAL AIR SUBSIDY PROGRAM

4.1 Criteria for Small Communities and Guidelines for Individual Determination of Essential Air Services

Under section 419 of the amended FAA, the CAB (DOT) is authorized to ensure the provision of essential air transportation, with subsidization if necessary, to small communities meeting certain eligibility requirements.

In accordance with the Act, an eligible point may be classified into two groups:

1. Under section 419(a), those communities that were served by not more than one certificated carrier on or subsequent to October 24, 1978 were eligible for EAS designation; and

2. Under section 419(b), those communities deleted from a carrier's certificate between July 1, 1968, and October 24, 1978, and any other communities in Alaska and Hawaii which the CAB designates as eligible could receive EAS designation.

The service guarantee was not extended to the communities for which air service between July 1, 1968 and October 24, 1978 was never provided by a certificated carrier, but was provided through an air taxi operator, a non-certificated third level carrier, or a commuter carrier. This was due to the fact that non-certificated carriers have virtually been deregulated since the early 1950s;[17] as such the points that were served by these carriers have been and remain totally dependent upon the marketplace. At the time the ADA was passed, there were approximately 200 such points; by 1983, about half had lost all of their air service.

In ensuring that essential air service is provided, the Act requires the Board (DOT) to issue essential air service determinations for eligible points such that each community and the carrier(s) serving them are aware of the required level of service. Section 419(a)(2) required the CAB (DOT) to issue determinations for all eligible points served by less than two certificated carriers on October 24, 1978. Similarly, the minimum required level of service was also issued for a community that was served by more than one certificated carrier on the date

of enactment but subsequently received service from only one carrier.

The designated hubs from which the essential air service is to be linked were described under section 419(f) of the Act:

> For purposes of this section, the term "essential air transportation" means scheduled air transportation of persons to a point provided under such criteria as the Board determines satisfies the needs of the community concerned for air transportation to one or more communities of interest and insures access to the Nation's air transportation system, at rates, fares, and charges which are not unjust, unreasonable, unjustly discriminatory, unduly preferential, or unduly prejudicial.

In Part 398 of the Rules and Regulations adopted on August 31, 1979, the CAB established Guidelines for Individual Determinations of Essential Air Transportation. The guidelines were intended to provide a framework for individual determinations and not as a specific formula.

4.1.1 Number and Designation of Hub

A hub is considered any point enplaning more than 0.05% of the total revenue passenger-miles in all services in the U.S. As a general rule, an eligible EAS point is one which requires service to only one hub, but in no cases more than two hubs. If an eligible EAS point has close ties to two hubs and there is sufficient traffic to support two round trips per day to both hubs, then the Board (DOT) may authorize such service to both hubs. If traffic is insufficient, the Board (DOT) may require only one round trip per day to both communities if such is requested.

In determining to which hub the service is to be linked, the Board (DOT) must consider several factors:

1. the degree to which the candidate hub provides convenient and adequate access to the national air transportation network;
2. the commercial, geographic, and political ties of the candidate hubs to the eligible point;
3. the historic traffic level to candidate hubs from the eligible point;
4. the distance between the points; and
5. the size of hub.

4.1.2 Equipment

While the Board (DOT) does not generally specify the size of aircraft providing the essential air service, the CAB (DOT) does require that:

1. all aircraft be sufficient to accommodate passengers and baggage;
2. larger aircraft be used over long distances;
3. all aircraft meet FAA safety standards;
4. all aircraft have two engines and two pilots except where otherwise agreed; and
5. aircraft be accessible to passengers by stairs rather than over the wing.

4.1.3 Frequency of Flights

For the lower 48 states, the policy of the CAB (DOT) in terms of frequency is to require at least two round trips on each weekday and two round trips over the weekend from the eligible point to the designated hub, unless the point was receiving less than that level in 1977 and cannot support service at a 50% average load factor. In Alaska, the Board (DOT) requires two round trips per week to each hub, or the level of service for the point that existed in 1976, whichever is greater.

The level of service may be extended beyond these general guidelines in certain cases, such as:

1. if historical traffic data indicate that more frequent service is warranted;
2. if more flights are needed because smaller aircraft are being used;
3. if more flights are needed because available capacity to the eligible point is being shared with traffic destined for some intermediate point;
4. for points in Alaska, if the Alaska Transportation Commission agrees that more frequent service is warranted; and
5. for communities with highly seasonal traffic, if a two-tier level of service could be implemented.

4.1.4 Maximum Capacity Guaranteed

The maximum available capacity to be guaranteed at an eligible point was established at 120 seats each day which can be translated into 60 seats from the hub to the eligible point and 60 seats from the eligible point to the hub. The capacity of 60 seats was chosen to accommodate 40 passengers outbound and 40 passengers inbound at a normal load factor of 65%. The limit was derived based on the assumption that self-sufficient operations can usually be attained at 40 passengers per day per direction.

The Board (DOT) can guarantee more than the 60-seat level:

1. if the available aircraft capacity for the eligible point is being shared with other intermediate stops;
2. if larger aircraft are required;
3. if the eligible point is extremely isolated;
4. if the eligible point has experienced a significant decrease in frequency and warrants an increase in the maximum capacity guaranteed; and
5. if unusual circumstances warrant such an increase.

4.1.5 Time of Flights

Essential air service flights must depart at reasonable times. The Board (DOT), in determining the reasonableness of the time, must consider the purpose for which the passengers are travelling. In the event that the purpose of travel is to connect with other flights, then the essential air service flights must be scheduled accordingly. If travel is local to and from the hub, then there should be one flight in the morning and one in the late afternoon or evening.

4.1.6 Number of Stops

A maximum of two stops is permitted in providing service between an eligible point and a hub unless otherwise agreed with the community. The Board (DOT) may require one-stop or non-stop service if necessary.

4.2 Methods of Determining Subsidy

In administering the section 419 subsidy program, the CAB was faced with the dual goal of ensuring reliability and continuous service to small communities while keeping the subsidy payments at reasonable levels. Section 419(d) of the amended FAA specifies that the subsidy should be "the fair and reasonable amount of compensation required to ensure the continuation of essential air transportation".

The focus of subsidy administration, therefore, is to encourage efficient and reliable carriers by having incentives built into the program. Three basic approaches to subsidy administration were considered by the Board (DOT) and they are summarized below:

4.2.1 Cost-Plus System

Under this approach, a maximum level of losses was to be established by the Board for carriers providing EAS service (i.e. the financial loss that the carrier was expected to sustain in providing essential service to the eligible point). The Board

then would have had to revise the subsidy downward or upward based on the carrier's actual performance. If a carrier's costs increased or revenues decreased, the subsidy would have had to increase under this method. Conversely, if the carrier's costs decreased or revenues increased, the subsidy would have decreased. The principle advantage of this approach is that it is easy to administer. Disadvantages of the cost-plus approach are that it does not offer the carrier any incentive to be cost-efficient nor to develop the market beyond the level of service deemed essential.

4.2.2 Fixed-Incentive Rate

The fixed-incentive approach is also based on a target loss but differs from the cost-plus system in that the carrier absorbs all losses in excess of the target. Under this method, the carrier could increase its profits by incurring losses below the targeted one. The fixed-rate approach has the advantage of being easy to administer and theoretically provides a strong incentive. Nevertheless, it also has certain disadvantages. For example, a carrier may be reluctant to accept the risk associated with the fixed rate unless it is sure that it can exceed the rate. Consequently, the Board (DOT) would have had to set a higher target in order to entice a carrier to provide the essential service. Furthermore, losses under the fixed rate may cutback or alter service to the community affected. This approach may also encourage carriers to initially provide service at low rates and subsequently threaten to withdraw service unless the rate is increased.

4.2.3 Shared-Incentive Rate

This approach represents a compromise between the cost-plus system and the fixed incentive rate. Under the shared incentive-rate approach, the Board (DOT) would have had to reimburse the carrier for a portion of the additional losses instead of all of them (as with the cost-plus system) or none of them (as with the fixed-rate system). This method provides the carrier with compensation for a predetermined, projected loss and an allowance for a reasonable profit.

This method, while offering the carrier some protection against disappointing results, provides a weaker incentive than the fixed-rate approach to control costs and develop markets. The sharing of excess losses reduces the possibility of service terminations or disruptions. A major disadvantage, however, is that the shared incentive rate is more burdensome with respect to administration and reporting.

In general, the CAB appeared to be in favour of the fixed-rate approach because of its stability and strong incentive to improve the particular service and also as it is relatively simple in terms of administration. However, in cases where

significant traffic growth is expected, the shared-incentive rate approach is generally favoured.

4.3 Performance Result of the Section 419 Program

The change from the section 406 to the section 419 subsidy program has had far-reaching effects on the growth of commuter operations and the development of small community air services. Under section 406, subsidies were based on the carriers' overall financial requirements, while under section 419, compensation is calculated on a specified minimum level of service. This change resulted in service levels to small communities which are more closely matched to actual demand. Under section 419, any capacity in excess of the minimum required level of service is no longer eligible for federal financial support. This, combined with the removal of market entry barriers, resulted in the establishment of commuter aircraft-oriented operations in low-density short-haul markets. As a consequence, 61 non-hub airports lost jet service between June 1, 1978 and June 1, 1984, and many small community air services have since become self-sufficient. (See Appendix C.)

Moreover, the section 419 subsidy program has deterred most of the local service carriers from serving the small community markets and has provided commuter carriers the opportunity to expand their operations in short-haul low-density markets. As a result, many small communities no longer require any federal financial support (as a general rule, when the enplanements exceed 30 passengers per day in the lower 48 states or 5 passengers per week in Alaska, a point can become subsidy free). At the same time, the market share of commuter carriers in the carriage of small community air passenger traffic, as measured by annual revenue passenger-kilometres, increased from 0.4% in 1975 to 11% in 1983.

The transition from the section 406 program to the section 419 program resulted in reductions in both the number of subsidized points and in total subsidy payments (see Table 4.1). In fact, the number of subsidized communities declined from 392 in fiscal year (FY) 1978 to approximately 134 in FY 1984, while subsidy payments decreased from about $75 million to approximately $36 million over the same period.

Under section 406 of the FAA, subsidies for small community air services were limited to a few certificated carriers and the subsidy concentration rate (measuring the extent to which subsidy payments were controlled by a limited number of large carriers) was very high. Each controlling carrier was in a position to operate the small community air services so as to best serve its own corporate objectives and hence the effectiveness of competition was likely lessened, leading to bigger subsidies and a higher rate of return earned by the

Table 4.1

COMPARISON OF RESULTS OF THE SECTION 406 AND SECTION 419 PROGRAMS

	Section 406 (FY 1978)		Section 419 (FY 1984)	
	No. of Points Subsidized	Total Subsidy Payments	No. of Points Subsidized	Total Subsidy Payments
Alaska	190*	$ 3 696 000	37	$ 4 658 000**
Hawaii	0	0	0	0
Lower 48 States and Other	202	$ 71 667 000	105	$31 339 000
	392	$ 75 363 000	142	$35 997 000

NOTES:* Due to difficulties in accurately arriving at the number of bush points subcontracted by the mainline operators in 1978, the number of subsidized points is a "ballpark" estimate.

** Under section 419(f), the EAS level in Alaska was guaranteed at the greater of either two round trips per week or the service level that existed in 1976. This resulted in an over-subsidization of $3 500 000 in 1984 involving jet service to five mainline points by Alaska Airlines (i.e. Cordova, Petersburg, Gustavus, Wrangell, and Yakutat.) This situation has subsequently been rectified inasmuch as after October 1986, the subsidy will be calculated according to the appropriate size of aircraft. As a consequence, the subsidies in Alaska are expected to fall to approximately $900 000 in 1987.

Sources:

1) CAB report to Congress - Implementation of the Provisions of the Airline Deregulation Act of 1978 - Jan. 31, 1984.

2) Information provided by the CAB.

carriers. As a result of the change-over from section 406 to section 419, as illustrated in Table 4.2, the number of carriers receiving federal subsidies increased from 11 in FY 1978 to 55 in FY 1984, while the average subsidies per carrier declined from $6.9 million to about $0.7 million over the same period. At the same time, the aggregate level of control on federal air service subsidies by the top four carriers dropped from 88.59% in FY 1978 to 32.18% in FY 1984 (see Table 4.3).

Despite the program's success, it is felt that the section 419 program could be further improved by incorporating the concept of isolation into the definition of eligible points. In 1983, an additional requirement on specifying EAS points in terms of 'isolation from major hubs' was recommended by the General Accounting Office to Congress. Should the recommendation be accepted, approximately 20 points, all of which are located within 100 miles from the nearest hubs presently included under the EAS program, would be eliminated from the section 419 subsidy program. This suggestion has yet to be reviewed by Congress.

4.4 Basic Requirements for the Program Application

Having briefly reviewed the U.S. Essential Air Services Program as per section 419 of the ADA, it appears that successful implementation of the program has the following requirements:

1. The presence of a well-developed commuter airline industry is essential for the development of this form of subsidy program. The type/size of aircraft in the fleet of commuter carriers is more appropriate to provide the designated frequencies, (i.e. two round trips per day) at points enplaning a small number of passengers per day. In preparing the ADA, Congress took into consideration the changing market environment in the small community air service and the growing success of the commuter airlines' operations in the low-density, short-haul markets. Prior to deregulation, there were more than 200 commuter airlines based in the United States and Puerto Rico, serving more than 800 airports.

2. The continuity of air service in small communities must be ensured; however, the right of existing carriers to abandon an EAS point under such a program is conditional upon the ready availability of suitable replacement carriers. This implies that this segment of the air transport industry is already reasonably mature and has a sufficient number of reliable, proven air carriers.

3. The possibility of providing excess capacity to a subsidized point should be avoided. To eliminate

Table 4.2

SUBSIDY DISTRIBUTION APPLIED TO
THE SECTION 406 AND SECTION 419 PROGRAMS

	Section 406 Program in FY 1978			Section 419 Program Estimated in FY 1984		
	Subsidy Payments	No. of Carriers Subsidized	Average Subsidy Per Carrier	Subsidy Payments	No. of Carriers Subsidized	Average Subsidy Per Carrier
Alaska	$ 3 696 000	3*	$1 232 000	$ 4 658 000	6	$ 776 333
Hawaii	0	0	0	0	0	0
Lower 48 States and Other	$71 667 000	8	$8 958 375	$31 339 000	49	$ 639 571
	$75 363 000	11	$6 851 000	$35 997 000	55	$ 654 491

* Subcontracted carriers are excluded from the study.

Sources:

1) CAB Form 470, Fiscal Year 1978.
2) CAB Form 470-A, Fiscal Year 1984.

Table 4.3

SUBSIDY CONCENTRATION APPLIED TO THE TOP FOUR CARRIERS

	Section 406 in FY 1978	Section 419 Estimated in 1984
Amount of subsidies received by the top four subsidized carriers	$66 763 000	$11 583 520
Total subsidy payments	$75 363 000	$35 997 000
The rate of subsidy concentration for the top four carriers	88.59%	32.18%

Sources:

1) CAB Form 470, Fiscal Year 1978.
2) CAB Form 470-A, Fiscal Year 1984.

any excess capacity, subsidy payments should be determined on the basis of the minimum required level of service.

4. The possible subsidy costs based on the long-term passenger projection at each EAS point must be thoroughly examined. (When considering the costs, any savings resulting from the cross-subsidization by other air services (cargo or mail) or by means of establishing a linear or cluster network configuration of neighbouring EAS points must be reflected.) Based on these considerations, the number of perpetually subsidized points can be derived. From the long-term prospect, the presence of a large number of perpetually subsidized points can be costly in the absence of alternative programs to reduce the burden to the public treasury and any indication that there may be significant long-term requirements for subsidies may suggest the need for less costly alternatives to ensure that the service is provided.

4.5 Empirical Testing of Factors Affecting Subsidy Determination

4.5.1 Purpose

The section 419 subsidy program has been in existence for over six years, and the transition from the section 406 program to the section 419 program has been fully completed. These events make it opportune to review the market characteristics of the subsidized communities, and to analyse the factors that affect the subsidy determinations, and the benefits received by the non-hub airports. The State of Alaska was excluded from the analysis in light of the unique features inherent in the subsidy assessment in Alaska.[18] As of March 5, 1984, approximately 480 communities in the 48 contiguous states had been included in a list of eligible points as defined under section 419 of the amended FAA (see Appendix D). Among these, approximately 110 communities still benefit from the Essential Air Services Program. In an effort to ascertain the factors which affect the subsidy determination and to measure the benefits received by the subsidized communities, the market characteristics of subsidized communities have been analysed and compared with those of non-subsidized non-hub airports. The next section explains the methodology used to differentiate the market characteristics of a subsidized community from the corresponding characteristics of a non-subsidized one.

4.5.2 Methodology

In order to quantify the difference in the market characteristics of these two groups, a discriminant analysis was conducted, followed by a classification procedure to which the

performance of the EAS program was further evaluated at an individual community level. The purpose of discrimination and classification is to find a discriminant function whereby a subsidized group can be separated from a non-subsidized one based on the value of the discriminant function. The function can be a linear or quadratic combination of the observed market characteristics. The detailed description of discrimination and classification is given in Appendix E. Having chosen the appropriate methodology, we can now proceed in collecting data which represent the market characteristics to be examined.

4.5.3 Variables and Data

Under the deregulated environment in the United States, the air carriers are relatively free to restructure their network configuration in such a way that theoretically profits may be maximized. The economic viability of a route is evaluated on the basis of its demographic, geographic, economic, and institutional characteristics. Therefore, a community which is disadvantaged according to these characteristics would, in the absence of an effective subsidy program, probably face substantial increases in fares and/or reductions in the level of service. As the communities with a less favourable market environment are best represented by non-hub airports, only such points were included in the study. The demographic characteristics can be represented by the size of population served by the non-hub airport. The geographic characteristics can be determined by the degree of isolation which can be measured in terms of the driving time required to reach the nearest air service centre where a significant level of air service can be obtained. The economic factors can be determined by the passenger demand, the level of service, and the number of carriers operating in the region. The institutional factors are the regulatory and fiscal regimes applied to air service in a non-hub airport.

The average fare per mile was selected as an indicator to measure the benefits of the EAS subsidy program. Subsequent to the passage of the ADA, all U.S. air carriers are free from any price regulation which has resulted in a fundamental change in the structure of fares. In essence, the pricing policy is still cost-oriented, but on a market-specific, rather than on a system-average basis. As a consequence, fare differences between markets are more likely to be the result of cost differences in these markets. Since the unit average cost of providing air service falls as the number of passengers per flight increases, assuming that the most appropriate aircraft was used, it is expected that unit costs and therefore fares would be higher for the small communities. However, the gap in unit fares between subsidized and non-subsidized points could be narrowed in the presence of an effective EAS program. Therefore, comparisons of unit fare levels between groups of subsidized and non-subsidized non-hub airports would afford an overview of the benefits

entailed in the EAS program within a relatively competitive market environment.

Having determined the forces that affect the subsidy program and the benefits accruing to the subsidized communities, the selection of appropriate variables to test the hypothesis was undertaken. The selected variables are described as follows:

1. Subsidy Status
   Since the purpose of the analysis is to discriminate between a subsidized community and a non-subsidized one, the subsidy status had to be established. The transition to a system-wide section 419 funding did not occur until the last quarter of 1983, and hence the subsidy status as of March 1, 1984 was selected.

2. Size of Population
   The number of inhabitants for Standard Metropolitan Statistical Areas (SMSA) in 1980 was used to measure the size of the population for each community. The general concept of a metropolitan area is one of a large population nucleus, together with adjacent communities which have a high degree of economic and social integration with that nucleus. Each SMSA has one or more central counties containing the area's main population concentration. An SMSA may also include outlying counties which have close economic and social relationships with the central counties.

3. Distance
   In accordance with the ADA, the Board was required to assign one or more hub(s) to an eligible point from which access to the national transportation network could be attained. To arrive at the most appropriate airlink between a community and a hub(s), the Board had to consider the commercial, geographic, and political ties of the candidate hub(s) to an eligible point and also the historical traffic levels to various hubs from that community. Once the CAB selected a list of designated hubs, the distance between the nearest air services centre and the small community was derived. The distance information was obtained from a CTC internal computer program.

4. Level of Service
   The weekly aircraft departures and corresponding seat capacity for the first week in June 1983 were selected to represent the level of service.

5. Market Demand
The level of 1982 annual enplanement was chosen to represent passenger demand for each community.

6. Competitive Pressure
The number of carriers operating in the community during the first week of June 1983 was selected to measure the degree of competition in providing air service to the community.

7. Unit Fare
Despite the fact that it was impossible to obtain the data showing the number of passengers travelling on each fare class, a fare variable was developed. This was based on either the lowest possible economy fare per kilometre or the lowest possible discount fare per kilometre, as offered in the first week of June 1983. From the list of eligible hubs compiled by the CAB, an average fare structure was derived for the city pairs specified for each EAS point. The difference between the average economy fare and the discount fare was also included in the analysis.

In light of limitations on data availability, the study was based on the economic, demographic, geographic, and institutional characteristics of 100 subsidized communities and 195 non-subsidized ones. The section which follows provides a summary of the results.

4.5.4 Results

Table 4.4 provides comparisons of group means together with the descriptive variables; it is apparent from the information that substantial differences between the two groups existed. Differences were observed in passenger demand, in the number of carriers operating in the community, in the spread between the unit economy fare and the unit discount fare, in the weekly available seat capacity, and in the weekly departures. On the other hand, there was virtually no difference in the group means of the unit economy fares (i.e. 32.15¢ per kilometre for the subsidized group as opposed to 32.21¢ per kilometre for the non-subsidized group). It is possible to conclude that within a relatively competitive market environment, the EAS points have benefitted from the program, inasmuch as unit economy fares for the EAS subsidized points are comparable with those observed in the non-subsidized non-hub airports. However, such benefits have not yet been extended in the case of discount fares, as the unit discount fares at the subsidized points are significantly higher than those at the non-subsidized points (i.e. an average of 28.98¢ per kilometre at the subsidized airports versus an average of 25.56¢ per kilometre at the non-subsidized ones).

Table 4.4

GROUP MEANS OF THE DESCRIPTIVE VARIABLES

Variables	Group Means	
	Subsidized Points	Non-subsidized Points
Population	19 149	46 630
Distance to the nearest air centre (kilometre)	241.5	225.4
Weekly available seats	407	2 231
Weekly departures	26	73
Passenger demand	2 201	24 686
No. of carriers operating in the point	1.23	2.17
Economy fare per kilometre	32.15¢	32.21¢
Discount fare per kilometre	28.98¢	25.56¢
Difference in fares per kilometre	3.1¢	6.8¢

The results of the multivariate discriminant analysis are summarized in Table 4.5 where expected signs, coefficients of the first canonical variate, and the associated group means are provided.

The direction of the relationship (positively or negatively related) between the subsidy status and the other variables is determined by the sign of the coefficients. In the case of a positive coefficient, the greater the magnitude, the greater is the chance of the community becoming self-sufficient. Conversely, in the case of a negative coefficient the greater the magnitude the greater is the chance of the community being subsidized. Since the signs of the coefficients applicable to the unit economy fares, distance to the nearest air service centre, the weekly departures, the number of carriers, and the population are contrary to the ones expected, these variables were excluded from the discriminant function.

The relative importance of the variables can be determined through reviewing the size of the standardized canonical coefficients. Clearly, the most important factor in establishing a discriminant function is passenger demand, as it contributes most in determining whether subsidized service is required for a non-hub airport. The least important factors are the differences in unit fares, and perhaps in the unit discount fares. Therefore, these latter variables were further discarded from the discriminant function.

The results of the linear discriminant function based on passenger demand and seat capacity are shown in Tables 4.6 and 4.7; the former describes the linear discriminant equations and the latter provides the test statistics. Based on the magnitude of the coefficients, passenger demand was still found to be far more important than the seat capacity in establishing a discriminant function and, as the Wilk's Lambda was relatively small, only a small amount of information remained unexplained.

To further improve the model, a quadratic discriminant function (QDF) was estimated. The result is,

$$QDF = 0.269762\ (Pax)^2 - 1.81086\ (Seat)^2 + 0.694417\ (Pax)(Seat) - 14.8693\ (Pax) + 17.2176\ (Seat) + 34.7138$$

Where: Pax = Ln (Passenger demand)
Seat = Ln (Seat capacity)

Figure 1 displays the original data with logarithmic transformation, along with the linear and quadratic discriminant functions. A community (X) was considered as belonging to the subsidized group, if the calculated value of the quadratic function for that community (Q(X)) was less than or equal to zero. Conversely, a community was placed into the non-subsidized group if the calculated value of the quadratic function was

Table 4.5

LINEAR DISCRIMINANT FUNCTIONS
(All Variables)

	Expected Signs	Standardized Coefficients (the first canonical variate)[19]	Group Means	
			Subsidized	Non-subsidized
Ln (population)	+	-0.1235		
Distance to the nearest air service centre	-	0.0253		
Ln (available seats)	+	0.1747		
Ln (weekly departures)	+	-0.0229		
Ln (passenger demand)	+	1.5856		
No. of carriers	+	-0.0892		
Economy fare per kilometre	-	0.2869		
Discount fare per kilometre	-	-0.1196		
Difference in fares (per kilometre basis)	+	0.0000		
Group means			-1.8233	0.9351

[19] The first canonical variate is the linear combination of a set of variables which maximizes the proportion of variance explained by the groups.

Figure 1
DISCRIMINANT FUNCTIONS

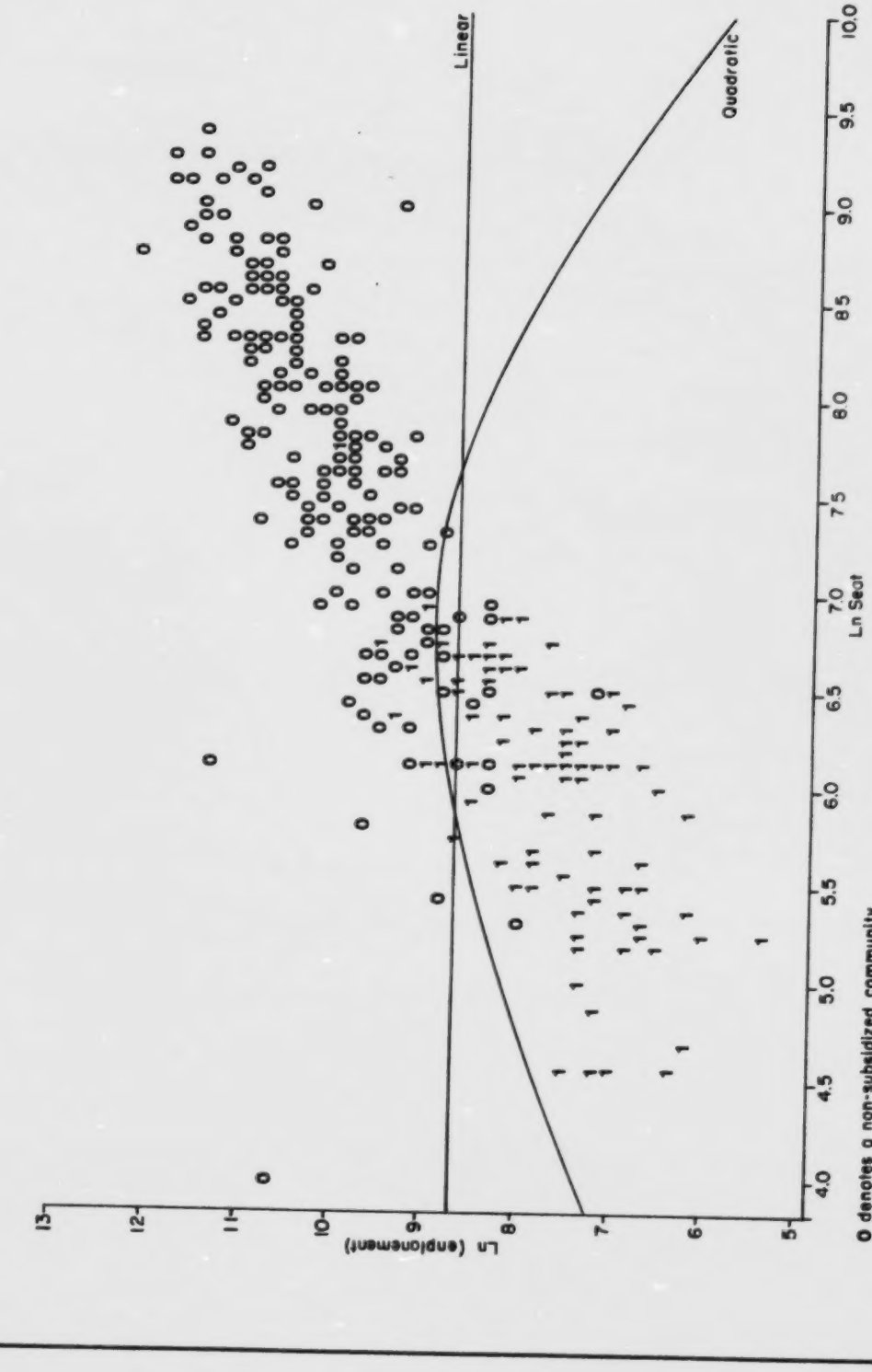

Table 4.6

LINEAR DISCRIMINANT FUNCTIONS
(Selected Variables)

	Canonical Coefficients (1st variate)		Fisher's Linear Discriminant Function
	Unstandardized	Standardized	
Constant	N.A.	N.A.	-25.985
Ln (passenger demand)	1.0801	1.5734	2.9013
Ln (seat capacity)	0.0442	0.0516	0.01189

Table 4.7

TEST STATISTICS FOR DISCRIMINANT FUNCTIONS

Statistics		Value
Adjusted canonical correlation		0.7835
Wilk's Lambda		0.3805
F Statistics		237.7
Degrees of freedom	- numerator	2
	- denominator	292
Probability greater than F		0.54E-62
Mahalanobis distances between groups		2.6863

greater than zero. Based on this type of classification rule, it was possible to derive the communities which should have been receiving and those which should have had their subsidy removed. Among a sample of 295 non-hubs, only 23 were found to be misclassified. Tables 4.8 and 4.9 summarize communities for which subsidies should be given and those for which subsidies should be removed.

According to the CAB (DOT) officials, the subsidy status at Elko, Roswell, Stockton, Modesto, Palmdale, and Sterling is expected to change in the forseeable future. While the former four points may soon be subsidy-free, the latter two points would remain subsidized. It was also found that the subsidy status at these points was highly related to the network configuration in conjunction with one or more nearby hubs. In essence, a low traffic non-hub airport can become subsidy-free as long as the service at the point can be provided together with other high traffic generating points. On the other hand, subsidies at some non-hubs were given on the basis that they are within the traffic range of other points where subsidies are warranted. Given the results, no significant improvement would be observed upon further refinements on the model, and hence no further analysis was required.

4.5.5 Findings of the Analysis

When comparing the market characteristics of subsidized communities with those of the non-subsidized ones, the differences are best exemplified through the measures of annual enplanements and weekly available seat capacity. For example, the average enplanements at the subsidized communities are only about 9% and average seat capacity 18% of the corresponding figures at the non-subsidized communities. At a subsidized community (facing both a low capacity and an even lower level of enplanements), it is reasonable to expect that higher revenue requirements, and hence higher fares would be required in order to assure air services in the absence of subsidies. However, when comparing the unit economy fare between the subsidized and non-subsidized communities, there is virtually no difference. The reason for this is that the economy fares at the subsidized communities were kept in line with the corresponding fares at the non-subsidized points through the financial assistance provided under section 419 of the FAA. In reviewing the orders issued by the CAB from 1979 onwards, total annual EAS subsidies accounted for approximately 40% of the carriers' estimated annual revenue requirements. Therefore, it is reasonable to postulate that without the EAS provisions, the ADA might have resulted in substantial increases in economy fares and/or the reduction, or the elimination of services at the currently subsidized communities.

Table 4.8

COMMUNITIES FOR WHICH SUBSIDIES ARE NOT PROVIDED AND WHICH WERE CLASSIFIED WITH THE SUBSIDIZED GROUP (11)

Communities	Annual Passengers	Weekly Available Seats as of June 1, 1983
Alpena, Mich.	3 974	396
Cape May, N.J.	4 229	969
Ft. Leonard Wood, Mo.	4 272	684
Galesburg, Ill.	4 729	633
Laconia, N.H.	4 344	469
Lovell, Wyo.	4 337	1 023
Marion Ill.	4 853	802
Mattoon, Ill.	1 921	468
Muncie, Ind.	5 342	468
Palmdale, Calif.	2 856	200
Sterling, Ill.	1 359	650

Table 4.9

COMMUNITIES FOR WHICH SUBSIDIES ARE PROVIDED AND WHICH WERE CLASSIFIED WITH THE NON-SUBSIDIZED GROUP (12)

Communities	Annual Passengers	Weekly Available Seats as of June 1, 1983
Alamogordo, N. Mex.	8 089	462
Elko, Nev.	10 169	756
Garden City, Kan.	7 935	1 045
Hays, Kans.	6 527	855
Modesto, Calif.	21 229	2 293
North Bend, Oreg.	6 357	450
Oil City, Pa.	7 513	703
Roswell, N. Mex.	12 910	836
Sault Ste. Marie, Mich.	5 957	324
Stockton, Calif.	60 093	3 979
Temple, Texas	6 381	468
Williston, N. Dak.	11 051	588

4.6 Summary and Conclusions

Without the U.S. EAS program, airline deregulation would have had a detrimental effect on about 100 small subsidized communities; both in terms of service levels and fares. With the transitional financial support of approximately $36 million air service to small U.S. communities has been maintained at the minimum required level. In contrast, the continuation of Canadian small community air service is guaranteed by retaining the regulatory regime in northern and remote areas as described under the new air liberalization policy announced by the then Minister of Transport on May 10, 1984. In the event that the policy be modified to reflect the ease of government intervention, the U.S. experience in dealing with the EAS program would offer valuable insights in terms of the Canadian situation. In particular, the U.S. experience is most pertinent in evaluating the costs and benefits associated with deregulation of northern and remote areas. For example, we may have to prepare ourselves for the possibility of instituting a subsidy program; if so, the nature of the program must be considered (i.e. transitional vs. perpetual, direct vs. indirect, and federal vs. provincial fundings).

Should a subsidy program be required, it is preferable that only a transitional one be considered. It must be noted that although temporary relief from potential hardship can be attained by means of transitional programs, these programs tend to lead to perpetual ones. Furthermore, the very nature of government assistance sometimes reflects, to a certain extent, the then-perceived public opinion and political pressures, rather than the social requirements or the logic of the marketplace.

Keeping this in mind, it must be ensured that even a transitional subsidy program has to be managed in a cost-efficient manner. This objective can be achieved by limiting the right of existing carriers to exit from a small community until a suitable replacement carrier can be found. In addition, the subsidy payments should be calculated on a specified minimum required level of service. Moreover, the presence of a well-developed commuter airline industry is essential for successful implementation of a small community air service program.

From the results derived from the discriminant analysis, it is possible to conclude that subsidized communities have benefitted from the EAS program. To arrive at the net social benefits of the program, the net of the consumers' and producers' surplus should be quantified. In the absence of an accurately measured demand curve for air services at the subsidized communities, the net social benefits were not derived in the study.

Chapter 5

IMPLICATIONS FOR CANADA

Having analysed the EAS program implemented in the U.S. under the Airline Derequlation Act, the next step is to investigate whether any sort of parallel between the analysis carried out for the U.S. program and the situation prevailing in Canada can be established. The reason for this is simple. In Canada, we also have a number of small communities which consider air services essential to their well-being. They are either located in the northern areas of the country or are isolated from the mainstream of activities. The air services provided to these areas have always had to comply with regulation.

A question comes to mind: are there any differences between what could be called the Canadian "essential air services" and the U.S. essential air services? To identify differences requires first the identification, in both countries, of communities receiving essential air services, and then, a comparison of the air services provided and an examination of the socio-economic characteristics of the said communities in both countries. Without going, at this stage, into a detailed analysis, from the Inquiry into the Adequacy of Air Services in Northern and Remote Areas of Canada, carried out in the summer of 1984 by the Air Transport Committee (ATC) of the CTC, it is possible to derive information about Canadian small communities that is pertinent to the identification of their particularities.

With respect to the nature of the services provided, the essential nature of air services in northern and remote areas is an undeniable reality; for many communities, there are no other alternatives. The services are essential in order: (a) to facilitate personal interaction with friends, relatives, and business colleagues elsewhere in Canada; (b) to access medical facilities; and (c) to obtain needed food supplies, building materials, and other vital essentials.

Another important characteristic identified in the ATC's report has to do with the fact that air services in northern and remote areas are more expensive to provide than in southern Canada and that air fares, as a consequence, are correspondingly higher.

Also, the manner in which the demand for air services throughout all northern and remote areas is met reflects the thinness, fragility, and seasonality of many of the markets; and

the ensuing satisfaction which is realized by consumers varies significantly from one area to another.

Within northern and remote areas, the ATC found the navigation aids and the infrastructure inappropriate which led the committee to identify the need for a long-term program for airport development. Finally, a social characteristic of the communities differentiates the situation in Canada from the situation in the U.S.; the relative importance of Native People as consumers or potential consumers of the services. They are so much so that the ATC, in its report, encourages "the air carriers to assist the Native People in making travel arrangements by providing, wherever feasible, telephone reservation services and related schedule information as well as airport check-in assistance and in-flight service announcements in the appropriate Native People's language".

The said features of "essential air services" in Canada cannot be forgotten in any plan to establish a program similar to the one analysed in the earlier sections of the text. The ATC panel which investigated the adequacy of air services in northern and remote areas made other recommendations which lie at the root of an EAS program for Canada. For instance, the panel was against the implementation of a direct subsidy program for air services in northern and remote areas. Instead, the panel felt that a capital asset acquisition program would enable air carriers to acquire appropriate aircraft. Finally, the panel was in favour of eliminating government fees, taxes, charges, etc. to bring down the cost of operations in northern and remote areas.

If the recommandations of the ATC report were to become the framework of an EAS program for Canada, it is evident that the specificities of air services in northern and remote areas would require a program custom-built to the Canadian situation. This is not meant to say that one could not take advantage of what was done under the EAS program in the U.S. The report has explained in detail the U.S. program. Having a better understanding of the U.S. EAS program, if Canada were to think seriously about implementing something similar, it is apparent that a thorough analysis of the Canadian small communities would be required to make the Canadian EAS program comply with the Canadian characteristics of remoteness.

REFERENCES

[1] Canadian Transport Commission. Final Report of the Air Transport Committee of the Canadian Transport Commission on the Adequacy of Air Services in Northern and Remote Areas, March 18, 1985.

[2] Economic Report of the President, 1975. (Washington: U.S. Government Printing Office, 1975)

[3] Section 1002 (d)(4)(A) and (d)(4)(B) of the Act.

[4] FEDERAL PREEMPTION

Preemption

Section 105. (a)(1) Except as provided in paragraph (2) of this subsection, no State or political subdivision thereof and no interstate agency or other political agency of two or more States shall enact or enforce any law, rule, regulation, standard, or other provision having the force and effect of law relating to rates, routes, or services of any air carrier having authority under title IV of this Act to provide interstate air transportation.

(2) Except with respect to air transportation (other than charter air transportation) provided pursuant to a certificate issued by the Board under section 401 of this Act, the provisions of paragraph (1) of this subsection shall not apply to any transportation by air of persons, property, or mail conducted wholly within the State of Alaska.

Proprietary Powers and Rights

(b)(1) Nothing in subsection (a) of this section shall be construed to limit the authority of any State or political subdivision thereof or any interstate agency or other political agency of two or more States as the owner or operator of an airport served by any air carrier certificated by the Board to exercise its proprietary powers and rights.

(2) Any aircraft operated between points in the same State (other than the State of Hawaii) which in the course of such operation crosses a boundary between two States, or between the United States and any other country, or between a State and the beginning of the territorial waters of the United States, shall not, by reason of crossing such boundary, be considered to be operating in interstate or overseas air transportation.

Existing State Authority

(c) When any interstate air carrier which on August 1, 1977, was operating primarily in intrastate air transportation regulated by a State receives the authority to provide interstate air transportation, any authority received from such State shall be considered to be part of its authority to provide air transportation received from the Board under title IV of this Act, until modified, suspended, amended, or terminated as provided under such title.

The above preemption provisions were implemented through the issuance of PS-82 and PS-83 in February 1979 in which interim rulings on economic regulation of intrastate carriers operating in pairs of points in Texas, Florida, and California were established. At the time of the passage of the Act, there was a marked difference between the intrastate and interstate fare policies. This was due to policies adopted by those states which kept the intrastate fares at an artificially low level. The fares in many intrastate markets were frequently 50% below the interstate fare for the same distances at the time PS-82 was adopted. In an effort to avoid a collision between the two systems and to prevent drastic changes in the interstate fare system, it was decided in PS-82 to standardize the levels by raising intrastate fare ceilings to be comparable with the level of the interstate fare ceilings through a gradual formula.

[5] Section 1002 (d)(6)(B) of the Act.

[6] The Board had subsequently exercised its authority in broadening the statutory zone of flexibility downwards as well as upwards. In 1980, full downward flexibility was incorporated into all markets. The statutory zone of flexibility was broadened in PS-92, PS-94, and PS-95 issued during the first half of 1980 and applied to intrastate as well as interstate markets). In PS-92, 10% upward flexibility was adopted for certain markets. The statutory zone of reasonableness was further widened in PS-94 where full downward flexibility was incorporated into all markets and full upward flexibility was allowed for flights up to 200 miles. For flights between 200 and 400 miles, airlines could set fares up to 50% above the SIFL, and for flights over 400 miles, 30% above. The intent of this policy was to rectify a downward bias against the SIFL in short-haul markets, as most fares in these markets were deliberately set below costs to conform with policies developed in the DPFI.

In light of the urgent need to accelerate the PS-82 timetable, the Board adopted PS-95 on June 17, 1980, which amended the Board's interim suspension policy on fare ceilings applied to intrastate pairs of points in California, Texas, and Florida. Effective immediately, fare ceilings for markets within California, Texas, or Florida would rise to their equivalent interstate ceilings. In conjunction with this, the zone of flexibility introduced in PS-94 also applied to these markets.

Subsequent to the issuance of PS-94, a motion for reconsideration was filed by 11 U.S. Senators. The public also addressed concerns on the fairness inherent in a mileage-based fare policy. In achieving its goal to rectify a downturn bias against short-haul markets established in the DPFI while arriving at a uniform zone of flexibility, the Board revised the upper limit at 30% above the cost adjusted SIFL plus $15, where $15 was the measure of the bias representing the adjustment to terminal costs. Finally, in accordance with section 1601(a)(2) of the Act, the Board's authority to regulate domestic fares ended on January 1, 1983.

Specifically, the standard industry fare levels (SIFL) between intrastate pairs of points, which were the fares charged on July 1, 1977 updated according to section 1002(d)(6) of the Act, were increased by 10% immediately to arrive at new fare ceilings. These new ceilings would be increased by 8% beginning on July 1, 1979, and every six months thereafter until either they reached the interstate fare ceilings or until January 1, 1981, at which time they all would be set at the interstate level.

[7] Although the Act was silent about the Board's authority on raising the upper limits, the Board maintained that in spite of the existence of the statutory zone, the Board's jurisdiction over fares outside the zone would not be relinquished during the transitional period. Therefore, in PS-92 the Board adopted 10% upward flexibility in certain markets with the following statements:

> By now allowing the carriers some pricing flexibility above the ceiling with limited risk of suspension, we are simply establishing guidelines for the exercise of our discretionary suspension power. We are not relinquishing our <u>jurisdiction</u> over fares outside the statutory zone. In this regard, (the) observation that Congress has expressly given us the authority to disclaim jurisdiction over the reasonableness of fares below the floor of the statutory zone by increasing the downward zone but failed to give us similar authority to increase the upward zone is correct. But it is not relevant.

[8] Under section 1601(a)(1) of the Act, provisions of the Act pertaining to interstate and overseas air transportation of persons and the Board's authority in conjunction with such provisions were to be terminated on December 31, 1981.

[9] The provision applied to:

> (i) any air carrier which (a) has operated during the preceding calendar year in accordance with a certificate issued by the Board under

this section which has been in force during such entire preceding calendar year, and (b) has provided air transportation of persons during such calendar year; and

(ii) any intrastate air carrier which has a valid certificate or license issued by a State regulatory authority to engage in intrastate air transportation and which has operated more than one hundred million available seat-miles in intrastate air transportation in the preceding calendar year.

[10] These two provisions of the Act were incorporated in the Board's Procedural Regulations 197 and 198.

[11] This provision was incorporated in PR-199.

[12] For detailed information, please see section 401(d)(5) of the Act and PR-180 adopted on October 18, 1978, or part 321 of the Board's Procedural Regulations.

[13] As of January 1, 1985, the CAB ceased to exist and the Department of Transport took over responsibility for most of the CAB's residual duties.

[14] Section 419 (b)(7) to section 419(b)(10) of the Act inclusive.

[15] Section 419(b)(7)(B) of the Act.

[16] Detailed information on the section 406 program is discussed in Section 3.2.

[17] Before the passage of the ADA, regulation of these carriers was limited to compliance with the limitations on aircraft size, payments of licence fees, and report-filing on a quarterly or on a semi-annual basis.

[18] Prior to the ADA, most of Alaska's Essential Air Service points were already receiving publicly funded service under the Local Air Services Program, section 406 of the FAA. For this reason, service withdrawals in Alaska as a result of deregulation have not taken place as they did in the rest of the country after the passage of the ADA.

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APPENDICES

Appendix A

A TRANSITION TO A DEREGULATED ENVIRONMENT IN ACCORDANCE WITH THE AIRLINE DEREGULATION ACT AND CIVIL AERONAUTICS BOARD'S RULINGS

Source Of Data		
CAB's Rulings	Sections Of The FAA As Amended By The ADA	Description Of The Deregulation Procedures
I. Fare Related		
PS-80 (Aug. 1978)		Fare ceilings and a non-suspended zone were established. The constraints associated with first-class fares and requirements on equal fare for equal distance were removed.
	1002(d)(6)(a)	The DPFI fare level on July 1, 1977 was selected as the Standard Industry Fare Level (SIFL) upon which a statutory zone was developed. (A 5% upward movement or a 50% downward movement was permitted.)
	105(a)	With exception of the State of Alaska, all the rule-making power on fares and routes by any state agency would thereupon be preempted so that CAB would become the sole economic regulator for the industry.
	1002(d)(4) and 1002(g)	After July 1, 1979, the CAB's power to suspend fares within a zone of reasonableness would be limited to that concerning predatory pricing.
	1002(d)(6)(b)	The SIFL had to be updated on not less than a semi-annual basis to reflect increases in operating costs.

	1002(d)(7)	The Board might, by rule, increase the percentage of the downward zone of reasonableness.
PS-82 (Feb. 1979)		In order to arrive at a uniform application of fare policies throughout the country as set out under the Federal Preemption of the ADA, a gradual formula was established to bring intrastate fare ceilings in line with the level of the interstate ceilings by January 1, 1981.
PS-94 (May 1980)		The statutory zone was further broadened to allow for full downward flexibility in all markets and full upward flexibility for flights up to 200 miles. For flights between 200 and 400 miles, carriers were permitted to set up fares up to 50% above the SIFL and for flights over 400 miles, 30% above.
PS-95 (June 1980)		The intrastate fare ceiling adjustment formula established in PS-82 was cancelled. Effective henceforth equivalent interstate fare ceilings would apply to these markets.
PS-96 (July 1980)		A full downward and 30% upward fare movement was introduced for Alaska, Hawaii, and Puerto Rico/Virgin Islands.
PS-98 (Oct. 1980)		The upper limit was revised at 30% above the cost adjusted SIFL plus $15 (i.e. (SIFL in 1977 + cost adjustment factor + $15) X 1.3.)

	1002(e) and 102(a)	It stated the Board's responsibilities under the ADA were to enforce on competitive markets (i.e. low fares, encouragement of entry, responsibilities toward public interest), and to ensure adequate service.
	204(a)	The Board retained its general powers to administer the Act as it deemed necessary to carry out its provisions and to exercise and perform its powers and duties under it.
	1601(a)(2)	The authority of the Board to regulate domestic fares would be terminated on January 1, 1983. In conjunction with this, the corresponding provisions of the FAA would also be terminated.
II. Market Entry		
	401(d)(7)(A)	Automatic market entry was introduced where the existing carriers could enter one route each year without the Board's approval during the transition period.
	401(d)(7)(c)	The existing carriers were allowed to protect one non-stop service each year.
PR-197 (Feb. 1979)		Procedural regulations pertaining to application for Automatic Market Entry program and Protection Permission.
PR-199 (March 1979)	401(d)(7)(d)(i)	The Board was required to modify the Automatic Market Entry program when the program operations

		were causing substantial public harm to the national air transportation system.
	401(d)(9)(B)	The burden of proof for route authority would be shifted from applicants to the opponent of such a route authority.
	401(c)(3) and 401(P)	The Board was required to establish simplified procedures to process applications.
PR-201 (April 1979)		The Board amended Part 302 of its Regulations in order to provide for simplified hearing procedures.
	1601(a)(1)	Regulation of market entry was to be terminated on December 31, 1981.
III. Market Exit		
	401(J)	Any carrier who wished to terminate, or reduce its service at one point below the minimum required level was required to file a notice to all affected parties at least 90 days before such change.
	419(b)(7) to 419(b)(10) incl.	In cases where no replacement carrier could be found, the incumbent carrier was required to maintain the minimum required service at the point with a "hold-in" compensation under the EAS Program.
PR-209 (July 1979)		"Procedures for compensating air carriers for losses" are incorporated into the CAB's regulations.

419(b)(7)(B)	The maximum length applied to the "hold-in" compensation paid to a trunk carrier is one year.
419(g)	The EAS Program would cease to be in effect on October 24, 1988.

Source of Data: Public Law 95-504
CAB Policy Statements. Procedural Regulations.
The information obtained from officials of the CAB.

Appendix B

SCHEDULE OF EVENTS IN CONJUNCTION WITH ESSENTIAL AIR TRANSPORTATION UNDER THE AIRLINE DEREGULATION ACT

October 24, 1978	The Airline Deregulation Act was passed. The sunset of the CAB was slated for the end of 1984 and there was to be a gradual easing of economic regulation over markets and fares. Small non-viable markets were protected by the Essential Air Services Subsidy until 1988. Two-fifths of the total EAS points were in Alaska.
No later than April 21, 1979	Safety standards for aircraft used by commuter carriers to provide service to eligible points were to be established.
No later than October 25, 1979	The level of Essential Air Transport was to be made for all eligible points described under section 419(a) (i.e. points served by one or no certificated carrier on or subsequent to October 24, 1978).
No later than January 1, 1980	Essential Air Service determinations were to be made for all eligible points described under section 419(b) (i.e. any points which has been deleted from a section 401 certificate between July 1, 1968 and October 24, 1978 and which the Board designates).
January 1, 1982 (onward)	New EAS points may be designated.
July 1, 1982	90-day suspension notices by carriers relying on the section 406 program which was to be determined were to be filed with the CAB.
September 1982	New Essential Air Service determinations were to be proposed by the CAB. Replacement carriers were to be sought by the CAB for points subject to suspension with existing carriers to continue services on a 30-days-at-a-time hold-in basis.

September 30, 1982	Termination of section 406 funding was to occur.
October 1, 1982	Commencement date of system-wide section 419 funding for air service in Alaska. A $13 500 000 Special Subsidy Program was to be provided to 4 local service carriers serving the 48 contiguous states. This program which was a hybrid section 406/section 419 subsidy was to expire in September 1983.
October 7, 1982	The last day for a carrier receiving a section 406 subsidy to file with the CAB for an emergency exemption from the specified 90-day suspension notice.
December 31, 1982	CAB tariff regulation was to cease -- including mandatory joint fares for service from rural to hub points.
January 1, 1983 (onward)	Provisions which allow bumping of section 406 carriers were to take effect. (In practice, no bumping has ever occurred.)
December 31, 1984	The CAB is to cease to exist; remaining regulatory functions are to be divided between other federal agencies, e.g. U.S. DOT, the Justice Department, State Department, and U.S. Postal Service.
September 1984	A Bill proposing the re-regulation of postal service rates charged by air carriers in Alaska is under review.
January 1, 1985	Postal Service is to set mail rates and undertake its own carrier selection proceedings.
October 25, 1988	Essential Air Service program is scheduled to cease to exist.

Source: Public Law 95-504, Airline Deregulation Act, October 24, 1978. Information provided by officials of the Civil Aeronautics Board.

Appendix C

SIXTY-ONE CITIES WHICH LOST JET SERVICE BETWEEN JUNE 1978 AND JUNE 1984

WEEKLY AIRCRAFT DEPARTURES

City	Weekly Aircraft Departures June 1978			Weekly Aircraft Departures June 1984		
	Jet	Non-Jet	Total	Jet	Non-Jet	Total
Aberdeen, S.D.	14	40	54	0	33	33
Alpena, Mich.	7	19	26	0	17	17
Bakersfield, Calif.	63	26	89	0	152	152
Beaumont/Port Arthur, Texas	41	77	118	0	267	267
Bend/Redmond, Oreg.	28	25	53	0	32	32
Burlington, Iowa	12	27	39	0	123	123
Cheyenne, Wyo.	14	104	118	0	93	93
Chico, Calif.	28	22	50	0	81	81
Columbus, Miss.	54	0	54	0	56	56
Decatur, Ill.	40	34	74	0	117	117
Dubuque, Iowa	14	96	110	0	153	153
Elko, Nev.	14	10	24	0	42	42
Ely, Nev.	14	0	14	0	42	42
Escanaba, Mich.	28	14	42	0	72	72
Florence, S.C.	14	66	80	0	116	116
Ft. Dodge, Iowa	12	12	24	0	45	45
Greenville, Miss.	41	0	41	0	37	37
Hancock/Houghton, Mich.	14	7	21	0	39	39
Hot Springs, Ark.	28	14	42	0	38	38
International Falls, Minn.	14	0	14	0	21	21
Iron Mountain, Mich.	42	0	42	0	38	38
Jamestown, N.D.	14	0	14	0	30	30
Klamath Falls, Oreg.	28	10	38	0	30	30
Lake Charles, La.	40	57	97	0	203	203
Laredo, Texas	21	0	21	0	64	64
Laurel/Hattiesburg, Miss.	13	21	34	0	61	61
Lawton, Okla.	27	114	141	0	76	76
Lewiston, Id./Clarkston, Wash.	28	59	87	0	154	154
Mankato, Minn.	7	20	27	0	35	35
Marion/Herrin, Ill.	6	22	28	0	70	70
Marquette, Mich.	21	0	21	0	82	82
Mason City, Iowa	14	24	38	0	70	70
Merced, Calif.	14	0	14	0	35	35
Meridian, Miss.	33	21	54	0	80	80
Modesto, Calif.	28	0	28	0	128	128

WEEKLY AIRCRAFT DEPARTURES

City	Weekly Aircraft Departures June 1978			Weekly Aircraft Departures June 1984		
	Jet	Non-Jet	Total	Jet	Non-Jet	Total
Muscle Shoals/Florence, Ala.	7	40	47	0	99	99
Muskegon, Mich.	35	46	81	0	103	103
Newport News, Va.	60	21	81	0	134	134
Paducah, Ky.	39	21	60	0	134	134
Parkersburg, W. Va.	20	63	83	0	80	80
Pendleton, Oreg.	20	19	39	0	30	30
Pocatello, Idaho	56	0	56	0	160	160
Presque Isle, Maine	14	52	66	0	71	71
Pueblo, Colo.	14	49	63	0	48	48
Quincy, Ill./Hannibal, Mo.	12	59	71	0	87	87
Riverton/Lander, Wyo.	7	14	21	0	89	89
Rockford, Ill.	28	10	38	0	73	73
Roswell, N.Mex.	7	7	14	0	113	113
Salem, Oreg.	14	36	50	0	12	12
Salina, Kansas	19	15	34	0	65	65
San Angelo, Texas	47	0	47	0	82	82
Sheridan, Wyo.	14	44	58	0	20	20
Texarkana, Ark.	27	0	27	0	73	73
Tuscaloosa, Ala.	47	0	47	0	38	38
Twin Falls, Idaho	49	25	74	0	61	61
Valdosta, Ga.	21	0	21	0	32	32
Visalia, Calif.	28	11	39	0	38	38
Watertown, S.D.	14	38	52	0	26	26
Wichita Falls, Texas	20	89	109	0	104	104
Worcester, Mass.	38	0	38	0	93	93
Yakima, Wash.	56	110	166	0	243	243
Total	1 543	1 710	3 253	0	4 796	4 796
Average per City	25.3	28.0	53.3	0.0	78.6	78.6

Source: Report on Airline Service, Fares, Traffic, Load Factors, and Market Shares, Dec. 1984.

Appendix D

DESIGNATED HUBS, FREQUENCY, AND THE MAXIMUM GUARANTEED SEAT CAPACITY SPECIFIED IN THE CIVIL AERONAUTICS BOARD'S ORDERS

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Anniston, Ala.	Atlanta, Ga.	A	0	160	320	
Dothan, Ala.	Atlanta, Ga.	A	1	160	320	
Gadsden, Ala.	Atlanta, Ga.	B	0	78	78	
Muscle Shoals, Ala.	Atlanta, Ga.	B	1			
	Memphis, Tenn.	B	1	160	292	
Florence, Ala.	Atlanta, Ga.	B	1			
	Memphis, Tenn.	B	1	160	292	
Sheffield, Ala.	Atlanta, Ga.	B	1			
	Memphis, Tenn.	B	1	160	292	
Tuscumbia, Ala.	Atlanta, Ga.	B	1			
	Memphis, Tenn.	B	1	160	292	
Tuscaloosa, Ala.	Atlanta, Ga.	A	1	160	320	
Flagstaff, Ariz.	Phoenix, Ariz.	A	0	160	320	
Grand Canyon, Ariz.	Las Vegas, Nev.	A	0	160	320	
Kingman, Ariz.	Phoenix, Ariz.	B	1	12	12	
Page, Ariz.	Las Vegas, Nev.	B	2	52	52	
	or, Phoenix, Ariz.	B	2			
Prescott, Ariz.	Phoenix, Ariz.	B	0	16	16	
Winslow, Ariz.	Phoenix, Ariz.	B	1	12	12	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Yuma, Ariz.	Los Angeles, Calif.	A	1	160	320	
	Phoenix, Ariz.	A	0			
El Dorado, Ark.	Dallas/Ft. Worth, Tex.	B	1			
	Memphis, Tenn.	B	1	100	100	
Camden, Ark.	Dallas/Ft. Worth, Tex.	B	1			
	Memphis, Tenn.	B	1	100	100	
Fayetteville, Ark.	Dallas/Ft. Worth, Tex.	A	1			
	Memphis, Tenn.	A	1	160	320	
	or, Kansas City, Mo.	A	1			
Ft. Smith, Ark.	Dallas/Ft. Worth, Tex.	A	1	160	320	
	Memphis, Tenn.	A	1			
Harrison, Ariz.	St. Louis, Mo.	B	1			
	Memphis, Tenn.	B	1	120	120	
	or, Dallas/Ft. Worth, Tex.	B	2			
Hot Springs, Ariz.	Dallas/Ft. Worth, Tex.	A	1			
	Memphis, Tenn.	A	1	160	320	
Jonesboro, Ariz.	Memphis, Tenn.	B	0	100	100	
Texarkana, Ariz.	Dallas/Ft. Worth, Tex.	A	1	160	320	
	Memphis, Tenn.	A	1			
Bakersfield, Calif.	San Francisco/Oakland, Calif.	A	0	160	320	
			0			
	Los Angeles, Calif.	A				
Blyth, Calif.	Los Angeles, Calif.	B	2	24	24	
Chico, Calif.	San Francisco/Oakland, Calif.	B	0	160	160	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	CAS (2) Weekday	CAS (2) Weekend	S. (3)
Crescent City, Calif.	San Francisco/Oakland, Calif.	B	2	56	56	
El Centro, Calif.	Los Angeles, Calif., or	A	1	160	320	
	San Diego, Calif.	A	0			
Eureka, Calif.	San Francisco/Oakland, Calif.	A	1	160	320	
Arcata, Calif.	San Francisco/Oakland, Calif.	A	1	160	320	
Merced, Calif.	Los Angeles, Calif.	B	2	44	44	
	San Francisco/Oakland, Calif.	B	0			
Inyokern, Calif.	Los Angeles, Calif.	B	1	112	112	
Lake Tahoe, Calif.	San Francisco/Oakland, Calif.	A	1	160	320	
Modesto, Calif.	San Francisco/Oakland, Calif.	A	0	160	160	
			1			
	Los Angeles, Calif.	A				
Monterey, Calif.	San Francisco/Oakland, Calif.	A	0			
			2	160	320	
	Los Angeles, Calif.	A				
Salinas, Calif.	San Francisco/Oakland, Calif.	A	0	160	320	
			2			
	Los Angeles, Calif.	A				
Orange County, Calif.	Los Angeles, Calif.	A	0	160	320	

Notes: (1) Frequency code is summarized in Attachment I.

(2) CAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Santa Ana, Calif.	Los Angeles, Calif.	A	0	160	320	
Anaheim, Calif.	Los Angeles, Calif.	A	0	160	320	
Oxnard, Calif.	Los Angeles, Calif.	A	0	160	320	
Ventura, Calif.	Los Angeles, Calif.	A	0	160	320	
Palmdales, Calif.	Los Angeles, Calif.	B	0	48	48	
Lancaster, Calif.	Los Angeles, Calif.	B	0	48	48	
Red Bluff, Calif.	San Francisco/Oakland, Calif.	A	1	160	320	
Redding, Calif.	San Francisco/Oakland, Calif.	A	1	160	320	
San Luis, Calif.	Los Angeles, Calif.	A	1	160	320	
Obispo, Calif.	San Francisco/Oakland, Calif.	A	1			
Paso Robles, Calif.	Los Angeles, Calif. San Francisco/Oakland, Calif.	A A	1 1	160	320	
Santa Barbara, Calif.	San Francisco/Oakland, Calif. Los Angeles, Calif.	A A	2 0	160	320	
Santa Maria, Calif.	San Francisco/Oakland, Calif. Los Angeles, Calif.	A A	0 0	160	320	
Santa Rosa, Calif.	San Francisco/Oakland, Calif.	B	0	160	320	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Stockton, Calif.	San Francisco/Oakland, Calif.	A	0	160	320	
			1			
	Los Angeles, Calif.	A				
Visalia, Calif.	San Francisco/Oakland, Calif.	B	1	160	160	
			1			
	Los Angeles, Calif.	B				
Alamosa, Colo.	Denver, Colo.	A	1	148	296	
Aspen, Colo.	Denver, Colo.	A	0	160	320	
Cortez, Colo.	Denver, Colo.	A	2	104	208	
Durango, Colo.	Denver, Colo.	A	1	160	320	
	Albuquerque, N. Mex.,	C	9			
	or Farmington, N. Mex.	C	9			
Gunnison, Colo.	Denver, Colo.	A	1	160	320	
Lamar, Colo.	Denver, Colo.	B	1	36	36	
Montrose, Colo.	Denver, Colo.	A	1	160	320	
Delta, Colo.	Denver, Colo.	A	1	160	320	
Pueblo, Colo.	Denver, Colo.	A	0	160	320	
Steamboat Springs, Colo.	Denver, Colo.	A	0	160	320	
Hayden, Colo.	Denver, Colo.	A	0	160	320	
Craig, Colo.	Denver, Colo.	A	0	160	320	
Bridgeport, Conn.	Boston, Mass.	B	1	140	140	
New Haven, Conn.	Boston, Mass.	B	1	160	320	
	New York, N.Y.	A	1			

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(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
New London, Conn.	New York, N.Y.	A	1	160	320	
Groton, Conn.	New York, N.Y.	A	1	160	320	
Stamford, Conn.	No determination required					
Eglin Air Force Base, Fla.	Atlanta, Ga.	A	1	160	320	
	New Orleans, La.	B	1			
Gainesville, Fla.	Atlanta, Ga.	A	1			
	Tampa/St. Petersburg,	A	0			
	Fla. or, Orlando, Fla.	A	0	160	320	
	or, Miami, Fla.	A	1			
Key West, Fla.	Miami, Fla.	A	0	160	320	
Lakeland, Fla.	No determination required					
Melbourne, Fla.	Atlanta, Ga.	A	1			
	Tampa/St. Petersburg,	B	0	160	320	
	Fla. or, Orlando, Fla.	B	0			
	or, Miami, Fla.	B	1			
Panama City, Fla.	Atlanta, Ga.	A	1			
	Tampa, Fla.	B	1	160	320	
	Orlando, Fla.	B	1			
Albany, Ga.	Atlanta, Ga.	A	0	160	320	
Athens, Ga.	Atlanta, Ga.	B	0	160	204	
Augusta, Ga.	Atlanta, Ga.	A	0	160	320	
Brunswick, Ga.	Atlanta, Ga.	B	1	160	160	S
Brunswick, Ga.	Atlanta, Ga.	B	1	130	130	W

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(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Columbus, Ga.	Atlanta, Ga.	A	0	160	320	
Macon, Ga.	Atlanta, Ga.	A	0	160	320	
Moultrie, Ga.	Atlanta, Ga.	B	1	72	72	
Thomasville, Ga.	Atlanta, Ga.	B	1	72	72	
Valdosta, Ga.	Atlanta, Ga.	B	1	160	304	
Waycross, Ga.	Atlanta, Ga.	B	1	40	40	
Lewiston, Idaho	Boise, Idaho	A	1	160	320	
	Spokane, Wash.	A	0			
Clarkston, Wash.	Boise, Idaho	A	1	160	320	
	Spokane, Wash.	A	0			
Sun Valley, Idaho	Boise, Idaho	N	0	80	80	S
	Salt Lake City, Utah	N	1			
Hailey, Idaho	Boise, Idaho	N	0	80	80	S
	Salt Lake City, Utah					
Ketchum, Idaho	Boise, Idaho	N	0	80	80	S
	Salt Lake City, Utah	N	1			
Sun Valley, Idaho	Boise, Idaho	N	0	160	320	W
	Salt Lake City, Utah	N	1			
Hailey, Idaho	Boise, Idaho	N	0	160	320	W
	Salt Lake City, Utah	N	1			
Ketchum, Idaho	Boise, Idaho	N	0	160	320	W
	Salt Lake City, Utah	N	1			

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(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Pocatello, Idaho	Salt Lake City, Utah	A	0	160	320	
	Boise, Idaho	A	1			
Twin Falls, Idaho	Boise, Idaho	A	0	160	320	
	Salt Lake City, Utah	A	1			
Bloomington, Ill.	Chicago, Ill.	A	0	160	320	
	St. Louis, Mo.	A	1			
Champaign, Ill.	Chicago, Ill.	A	0	160	320	
	St. Louis, Mo.	A	1			
Urbana, Ill.	Chicago, Ill.	A	0	160	320	
	St. Louis, Mo.	A	1			
Danville, Ill.	Chicago, Ill.	B	0	160	160	
Decator, Ill.	Chicago, Ill.	A	1	160	320	
	St. Louis, Mo.	A	0			
Galesburg, Ill.	Chicago, Ill.	B	1	104	104	
Marion, Ill.	St. Louis, Mo.	A	0	160	320	
Herrin, Ill.	St. Louis, Mo.	A	0	160	320	
Mattoon, Ill.	Chicago, Ill.	B	1	92	92	
	St. Louis, Mo.	B	1			
Charleston, Ill.	Chicago, Ill.	B	1	92	92	
	St. Louis, Mo.	B	1			
Mount Vernon, Ill.	St. Louis, Mo.	B	0	100	100	
Quincy, Ill.	Chicago, Ill.	A	1	160	320	
	St. Louis, Mo.	A	0			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Hannibal, Mo.	Chicago, Ill.	A	1	160	320	
	St. Louis, Mo.	A	0			
Rockford, Ill.	Chicago, Ill.	A	0	160	320	
Springfield, Ill.	Chicago, Ill.	A	0	160	320	
	St. Louis, Mo.	A	0			
Sterling, Ill.	Chicago, Ill.	B	0	58	58	
Rock Falls, Ill.	Chicago, Ill.	B	0	58	58	
Bloomington, Ind.	Chicago, Ill.	A	1	160	320	
	Indianapolis, Ind.	A	0			
Elkhart, Ind.	Chicago, Ill.	A	0	160	320	
Kokomo, Ind.	Chicago, Ill.	B	0	24	24	
Logansport, Ind.	Chicago, Ill.	B	0	24	24	
Peru, Ind.	Chicago, Ill.	B	0	24	24	
Lafayette, Ind.	Chicago, Ill.	A	0	160	320	
Muncie, Ind.	Chicago, Ill.	B	1	132	264	
Anderson, Ind.	Chicago, Ill.	B	1	132	264	
New Castle, Ind.	Chicago, Ill.	B	1	132	264	
Terre Haute, Ind.	Chicago, Ill.	A	1	160	320	
	Indianapolis, Ind.	A	0			
Burlington, Iowa	Chicago, Ill.	A	1	160	320	
	St. Louis, Mo.	A	1			
Clinton, Iowa	Chicago, Ill.	B	0	44	44	

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(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	CAS (2) Weekday	CAS (2) Weekend	S. (3)
Dubuque, Iowa	Chicago, Ill.	A	1			
	Omaha, Nebr.	A	2	160	320	
	or, Des Moines, Iowa	A	1			
	or, Minneapolis/St. Paul, Minn.	A	2			
Ft. Dodge, Iowa	Chicago, Ill.	B	1			
	or, Minneapolis/St. Paul, Minn.	B	0	80	80	
	or, Des Moines, Iowa	B	0			
	or, Omaha, Neb.	B	0	160	160	
Mason City, Iowa	Chicago, Ill.	B	1			
Ottumwa, Iowa	Chicago, Ill.	B	1			
	or, Des Moines, Iowa	B	0	64	64	
	Moline, Ill.	B	0			
Waterloo, Iowa	Chicago, Ill.	A	2			
Denver, Colo.	Denver, Colo.	A	2			
	or, Kansas City, Mo.	A	2	160	320	
	or, Minneapolis/St. Paul, Minn.	A	1			
	or, Omaha, Nebr.	A	1			
Dodge City, Kans.	Denver, Colo.	B	2			
	Kansas City, Mo.	B	2	80	80	
	or, Wichita, Kans.	B	0			
Garden City, Kans.	Denver, Colo.	B	2			
	Kansas City, Mo.	B	2	112	112	
	or, Wichita, Kans.	B	1			
Goodland, Kans.	Denver, Colo.	B	1	38	38	
Great Bend, Kans.	Kansas City, Mo.	B	1	64	64	
	Wichita, Kans.	B	0			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Hays, Kans.	Denver, Colo.	B	2			
	Kansas City, Mo.	B	2	124	124	
	or, Wichita, Kans.	B	1			
Hutchinson, Kans.	Wichita, Kans.	B	0	28	28	
Independence, Kans.	Kansas City, Mo.	B	0	44	44	
Coffeyville, Kans.	Kansas City, Mo.	B	0	44	44	
Parsons, Kans.	Kansas City, Mo.	B	0			
Liberal, Kans.	Denver, Colo.	A	2			
	Oklahoma City, Okla.	A	1	152	304	
	or, Wichita, Kans.	A	1			
Guymon, Okla.	Denver, Colo.	A	2			
	Oklahoma City, Okla.	A	1	152	304	
	or, Wichita, Kans.	A	1			
Manhattan, Kans.	Kansas City, Mo.	A	0	160	320	
Junction City, Kans.	Kansas City, Mo.	A	0	160	320	
Ft. Riley, Kans.	Kansas City, Mo.	A	0	160	320	
Salina, Kans.	Kansas City, Mo.	A	1			
	Denver, Colo.	A	2	160	320	
	or, Wichita, Kans.	A	0			
Topeka, Kans.	Kansas City, Mo.	A	0	160	320	
London, Ky.	Louisville, Ky.	B	1	36	36	
Corbin, Ky.	Louisville, Ky.	B	1	36	36	

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Owensboro, Ky.	Louisville, Ky.	B	0	144	144	
Paducah, Ky.	St. Louis, Mo.	A	1	160	320	
Alexandria, La.	Dallas/Ft. Worth, Tex. New Orleans, La.	A A	2 1	160	320	
Lafayette, La.	Houston, Tex. New Orleans, La.	A A	1 0	160	320	
Lake Charles, La.	Houston, Tex. New Orleans, La.	A A	0 1	160	320	
Shreveport, La.	Determination withdrawn					
Augusta, Maine	Boston, Mass.	A	0	160	320	
Waterville, Maine	Boston, Mass.	A	0	160	320	
Bangor, Maine	Boston, Mass.	A	0	160	320	
Bar Harbour, Maine	Boston, Mass.	A	1	160	320	S
Bar Harbour, Maine	Boston, Mass.	B	1	84	84	W
Lewiston, Maine	Boston, Mass.	B	1	36	36	
Auburn, Maine	Boston, Mass.	B	1	36	36	
Portland, Maine	Boston, Mass.	A	0	160	320	
Presque Isle, Maine	Boston, Mass.	A	0	160	320	
Houlton, Maine	Boston, Mass.	A	0	160	320	

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Rockland, Maine	Boston, Mass.	B	1	160	160	S
Rockland, Maine	Boston, Mass.	B	1	116	116	W
Hagerstown, Md.	Baltimore, Md.	A	0	160	320	
	or, Washington, D.C.	A	0			
Martinsburg, W. Va	Baltimore, Md.	A	0	160	320	
	or, Washington, D.C.	A	0			
Salisbury, Md.	Baltimore, Md.	A	0	160	320	
	or, Washington, D.C.	A	0			
Hyannis, Mass.	Boston, Mass.	A	0	160	320	S
	New York City, N.Y.	A	1			
Hyannis, Mass.	Boston, Mass.	A	0	160	320	W
	New York City, N.Y.	B	1			
Martha's Vineyard, Mass.	Boston, Mass.	A	1	160	320	S
	New York City, N.Y.	A	1			
Martha's Vineyard, Mass.	Boston, Mass.	A	1	160	320	W
Nantucket, Mass.	Boston, Mass.	A	1	160	320	
	Hyannis, Mass.	A	0			
New Bedford, Mass.	Nantucket, Mass.	A	1	52	104	S
Fall River, Mass.	Nantucket, Mass.	A	1	52	104	S
New Bedford, Mass.	Nantucket, Mass.	B	1	28	28	W

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Fall River, Mass.	Nantucket, Mass.	B	1	28	28	W
New Bedford, Mass.	Nantucket, Mass.	B	1	28	28	W
Fall River, Mass.	Nantucket, Mass.	B	1	28	28	W
Worcester, Mass.	New York City, N.Y.	A	0	160	320	
Alpena, Mich.	Detroit, Mich.	A	1	140	280	
Benton Harbour, Mich.	Chicago, Ill.	A	0	160	320	
St. Joseph, Mich.	Chicago, Ill.	A	0	160	320	
Escanaba, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1			
	or, Milwaukee, Wis.	A	1			
Flint, Mich.	Chicago, Ill.	A	2	160	320	
	or, Detroit, Mich.	A	0			
Hancock, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1			
	or, Milwaukee, Wis.	A	2	160	320	
Houghton, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1	160	320	
	or, Milwaukee, Wis.	A	2			
Iron Mountain, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	10	160	320	
	or, Milwaukee, Wis.	A	1			
Kingsford, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	0	160	320	
	or, Milwaukee, Wis.	A	1			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Ironwood, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1	142	284	
	or, Milwaukee, Wis.	A	2			
	or, Minneapolis/St. Paul, Minn.	A	1			
Ashland, Wis.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1	142	284	
	or, Milwaukee, Wis.	A	2			
	or, Minneapolis/St. Paul, Minn.	A	1			
Jackson, Mich.	Chicago, Ill.	A	1	112	224	
	Detroit, Mich.	A	0			
Kalamazoo, Mich.	Chicago, Ill.	A	0	160	320	
	Detroit, Mich.	A	0			
Battle Creek, Mich.	Chicago, Ill.	A	0	160	320	
	Detroit, Mich.	A	0			
Manistee, Mich.	Chicago, Ill.	F	1	32	64	
Ludington, Mich.	Chicago, Ill.	F	1	32	64	
Marinette, Wis.	or, Green Bay, Wis.	A	0	114	228	
	or, Milwaukee, Wis.	A	1			
Menominee, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	0	114	228	
	or, Milwaukee, Wis.	A	1			
Marquette, Mich.	Chicago, Ill.	A	2			
	or, Green Bay, Wis.	A	1	160	320	
	or, Milwaukee, Wis.	A	1			
Pellston, Mich.	Chicago, Ill.	G	2	160	320	
	Detroit, Mich.	A	1			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Muskegon, Mich.	Chicago, Ill.	A	1	160	320	
	Detroit, Mich.	A	1			
Sault St. Marie, Mich.	Detroit, Mich.	B	2	108	108	
Traverse City, Mich.	Chicago, Ill.	A	1	160	320	
	Detroit, Mich.	A	1			
Bemidji, Minn.	Minneapolis/St. Paul, Minn.	A	1	160	320	
Brainerd, Minn.	Minneapolis/St. Paul, Minn.	A	0	136	272	
Chisholm, Minn.	Minneapolis/St. Paul, Minn.	A	1	160	320	
Hibbing, Minn.	Minneapolis/St. Paul, Minn.	A	1	160	320	
Duluth, Minn.	Minneapolis/St. Paul, Minn.	A	0	160	320	
	Chicago, Ill.	A	2			
Superior, Wis.	Minneapolis/St. Paul, Minn.	A	0	160	320	
	Chicago, Ill.	A	2			
Fairmont, Minn.	Minneapolis/St. Paul, Minn.	B	1	76	76	
International Falls, Minn.	Minneapolis/St. Paul, Minn.	A	2	160	320	S
International Falls, Minn.	Minneapolis/St. Paul, Minn.	B	2	116	58	W
Mankato, Minn.	Minneapolis/St. Paul, Minn.	B	0	92	92	

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Thief River Falls, Minn.	Minneapolis/St. Paul, Minn.	A	2	112	224	
Winona, Minn.	Minneapolis/St. Paul, Minn.	K	0	20	0	
Worthington, Minn.	Minneapolis/St. Paul, Minn.	B	2	32	32	
Columbus, Miss.	Atlanta, Ga.	A	1	160	320	
	Memphis, Tenn.	A	0			
Greenville, Miss.	Memphis, Tenn.	L	0	160	160	
Greenwood, Miss.	Memphis, Tenn.	B	1	32	32	
Gulfport, Miss.	Atlanta, Ga.	A	2	160	320	
	New Orleans, La.	A	0			
Biloxi, Miss.	Atlanta, Ga.	A	2	160	320	
	New Orleans, La.	A	0			
Jackson, Miss.	Atlanta, Ga.	A	1	160	320	
	New Orleans, La.	A	0			
Vicksburg, Miss.	Atlanta, Ga.	A	1	160	320	
	Dallas/Ft. Worth, Tex.	A	1			
Laurel, Miss.	Atlanta, Ga.	A	2	160	320	
	Memphis, Tenn.	A	2			
	or, Minneapolis/St. Paul, Minn.	A	0			
Hattiesburg, Miss.	Atlanta, Ga.	A	2			
	Memphis, Tenn.	A	2	160	320	
	or, Minneapolis/St. Paul, Minn.	A	0			
Meridian, Miss.	Atlanta, Ga.	A	2	160	320	
	Memphis, Tenn.	A	1			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Natchez, Miss.	Minneapolis/St. Paul, Minn.	B	1	20	20	
Tupelo, Miss.	Atlanta, Ga.	B	1	160	320	
	Memphis, Tenn.	B	0			
University, Miss.	Memphis, Tenn.	B	0	24	24	
Oxford, Miss.	Memphis, Tenn.	B	0	24	12	
Cape Girardeau, Mo.	St. Louis, Mo.	A	1	160	320	
Sikeston, Mo.	St. Louis, Mo.	A	1	160	320	
Columbia, Mo.	St. Louis, Mo.	A	0	160	320	
	Kansas City, Mo.	A	0			
Jefferson City, Mo.	St. Louis, Mo.	A	0			
	Kansas City, Mo.	A	0	160	160	
Ft. Leonard Wood, Mo.	St. Louis, Mo.	B	0	144	144	
Kirksville, Mo.	St. Louis, Mo.	B	1	32	32	
Springfield, Mo.	St. Louis, Mo.	A	1	160	320	
	Kansas City, Mo.	A	1			
Glasgow, Mont.	Billings, Mont.	B	2	20	20	
Glendive, Mont.	Billings, Mont.	B	2	12	12	

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Harve, Mont.	Great Falls, Mont.	B	0	12	12	
Lewiston, Mont.	Billings, Mont.	B	0	4	4	
Miles City, Mont.	Billings, Mont.	B	1	8	8	
Sidney, Mont.	Billings, Mont.	B	2	28	28	
West Yellow-stone, Mont.	Denver, Colo.	A	2	160	320	S
	Salt Lake City, Utah	A	2			S
West Yellow-stone, Mont.	Denver, Colo.	G	2	80	160	W
	Salt Lake City, Utah	G	2			W
Wolf Point, Mont.	Billings, Mont.	B	2	24	24	
Alliance, Nebr.	Denver, Colo.	B	1	42	42	
Chadron, Nebr.	Denver, Colo.	B	1	38	38	
Columbus, Nebr.	Omaha, Nebr.	B	0	16	16	
Grand Island, Nebr.	Denver, Colo.	A	2	160	320	
	Omaha, Nebr.	A	1			
Hastings Nebr.	Omaha, Nebr.	B	1	68	68	
Kearney, Nebr.	Omaha, Nebr.	B	2	76	76	
McCook, Nebr.	Denver, Colo.	B	1	44	44	
Norfolk, Nebr.	Omaha, Nebr.	B	0	80	80	
North Platte, Nebr.	Denver, Colo.	A	1	160	320	
	Omaha, Nebr.	B	2			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Scottsbluff, Nebr.	Denver, Colo.	A	1			
	Lincoln, Nebr.	B	2	160	320	
	Omaha, Nebr.	B	2			
Sidney, Nebr.	Denver, Colo.	B	0	28	28	
Elko, Nev.	Reno, Nev.	A	1	132	264	
	Salt Lake City, Utah	A	1			
	Salt Lake City, Utah	A	1	52	104	
Ely, Nev.	Reno, Nev.	A	1	52	104	
	Salt Lake City, Utah	A	1			
Berline, N.H.	Determination withdrawn					
Keene, N.H.	Boston, Mass.	A	0	144	288	
	New York City, N.Y.	A	2			
Laconia, N.H.	Boston, Mass.	B	1	64	64	
	New York City, N.Y.	B	1			
Lebanon, N.H.	Boston, Mass.	A	0	160	320	
	New York City, N.Y.	A	1			
White River Junction, N.H.	Boston, Mass.	A	0	160	320	
	New York City, N.Y.	A	1			
Manchester, N.H.	Boston, Mass.	A	0	160	320	
	New York City, N.Y.	A	0			
Concord, N.H.	Boston, Mass.	A	0	160	320	
	New York City, N.Y.	A	0			
Atlantic City, N.J.	Philadelphia, Pa.	A	0	160	320	

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Cape May, N.J.	Philadelphia, Pa.	A	1	160	320	S
Cape May, N.J.	Philadelphia, Pa.	B	1	76	76	W
Peterboro, N.J.	No determination required					
Trenton, N.J.	Philadelphia, Pa.	B	0	160	160	
Alamogordo, N. Mex.	Albuquerque, N. Mex.	B	1	108	108	
Carlsbad, N. Mex.	Albuquerque, N. Mex.	B	1	108	108	
Clovis, N. Mex.	Albuquerque, N. Mex.	B	1	108	108	
Farmington, N. Mex.	Albuquerque, N. Mex.	A	0	160	320	
	Denver, Colo.	A	2			
Gallup, N. Mex.	Albuquerque, N. Mex.	B	0	152	152	
Hobbs, N. Mex.	Albuquerque, N. Mex.	B	1	100	100	
Roswell, N. Mex.	Albuquerque, N. Mex.	A	0	160	320	
	Midland, Tex.	B	1			
	Lubbock, Tex.	B	1			
Santa Fe, N. Mex.	Albuquerque, N. Mex.	B	0	56	56	
	Denver, Colo.	B	2			
Silver City, N. Mex.	Albuquerque, N. Mex.	B	1	64	64	
Hurley, N. Mex.	Albuquerque, N. Mex.	B	1	64	64	
Deming, N. Mex.	Albuquerque, N. Mex.	B	1	64	64	
Binghamton, N.Y.	New York City, N.Y.	A	0	160	320	
	Pittsburg, Pa.	A	1			
Endicott, N.Y.	New York, City, N.Y.	A	0	160	320	
	Pittsburg, Pa.	A	1			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Johnson City, N.Y.	New York City, N.Y.	A	0	160	320	
	Pittsburg, Pa.	A	1			
Elmira, N.Y.	New York City, N.Y.	A	1	160	320	
	Pittsburg, Pa.	A	1			
Corning, N.Y.	New York City, N.Y.	A	1	160	320	
	Pittsburg, Pa.	A	1			
Glens Falls, N.Y.	Determination withdrawn					
Islep, N.Y.	New York City, N.Y.	B	0	160	160	
Cortland, N.Y.	New York City, N.Y.	A	1	160	320	
	Pittsburg, Pa.	A	1			
Ithaca, N.Y.	New York City, N.Y.	A	1	160	320	
	Pittsburg, Pa.	A	1			
Jamestown, N.Y.	Pittsburg, Pa.	A	1	160	320	
	Buffalo, N.Y.	A	1			
Catskills, N.Y.	Determination withdrawn					
Sullivan County, N.Y.	Determination withdrawn					
Massena, N.Y.	Syracuse, N.Y.	B	2	56	56	
Ogdensburg, N.Y.	Syracuse, N.Y.	B	1	52	52	
Plattsburg, N.Y.	Albany, N.Y.	B	1	116	116	
Poughkeepsie, N.Y.	New York City, N.Y.	B	1	160	160	
Rockville Centre, N.Y.	No determination required					

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Saranac Lake, N.Y.	Albany, N.Y.	B	0	80	80	
Lake Placid, N.Y.	Albany, N.Y.	B	0	80	80	
Utica, N.Y.	New York City, N.Y.	A	1	160	320	
Rome, N.Y.	New York City, N.Y.	A	1	160	320	
Watertown, N.Y.	Syracuse, N.Y.	B	0	64	64	
White Plains, N.Y.	New York City, N.Y.	J	0	160	0	
Ashville, N.C.	Charlotte, N.C.	A	0	160	320	
Fayetteville, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	0			
	Norfolk, Va.	A	1			
	or, Raleigh, N.C.	A	0	160	320	
Fayetteville, N.C.	or, Richmond, Va.	A	1			
	or, Washington, D.C.	A	2			
Hickory, N.C.	Charlotte, N.C.	B	0	160	320	
Jacksonville, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	1			
	Raleigh, N.C.	A	0			
	or, Richmond, Va.	A	1	160	320	
	or, Norfolk, Va.	A	1			
	or, Washington, D.C.	A	2			
Camp Lejeune, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	1			
	Raleigh, N.C.	A	0	160	320	
	or, Richmond, Va.	A	1			
	or, Norfolk, Va.	A	1			
	or, Washington, D.C.	A	2			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Kinston, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	1			
	Raleigh, N.C.	A	0			
	or, Richmond, Va.	A	0	160	320	
	or, Norfolk, Va.	A	0			
	or, Washington, D.C.	A	1			
Goldsboro, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	1			
	Raleigh, N.C.	A	0	160	320	
	or, Richmond, Va.	A	0			
	or, Norfolk, Va.	A	0			
	or, Washington, D.C.	A	1			
Greenville, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	1			
	Raleigh, N.C.	A	0			
	or, Richmond, Va.	A	0	160	320	
	or, Norfolk, Va.	A	0			
	or, Washington, D.C.	A	1			
Morehead City, N.C.	Charlotte, N.C.	B	0	78	78	
	or, Raleigh, N.C.	B	0			
Beaufort, N.C.	Charlotte, N.C.	B	0	78	78	
	or, Raleigh, N.C.	B	0			
New Bern, N.C.	Charlotte, N.C.	B	0	78	78	
	or, Raleigh, N.C.	B	0			
Rocky Mount, N.C.	Raleigh, N.C.	K	0			
	or, Charlotte, N.C.	K	1	32	0	
Wilson, N.C.	Raleigh, N.C.	K	0	32	0	
	or, Charlotte, N.C.	K	1			

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Wilmington, N.C.	Atlanta, Ga.	A	2			
	or, Charlotte, N.C.	A	0			
	Raleigh, N.C.	A	0	160	320	
	or, Norfolk, Va.	A	1			
	or, Richmond, Va.	A	1			
	or, Washington, D.C.	A	2			
Winston-Salem, N.C.	Charlotte, N.C.	B	0	160	320	
Devils Lake, N. Dak.	Bismark, N. Dak.	B	0	44	44	
	Minneapolis/St. Paul, Minn.	B	2			
Fargo, N. Dak.	No determination made					
Moorhead, Minn.	No determination made					
Jamestown, N. Dak.	Minneapolis/St. Paul Minn.	B	2	30	30	
Williston, N. Dak.	Bismark, N. Dak.	B	1	140	140	
	Billings, Mont.	B	3			
Akron, Ohio	Chicago, Ill.	A	2	160	320	
	Pittsburg, Pa.	A	0			
Canton, Ohio	Chicago, Ill.	A	2	160	320	
	Pittsburg, Pa.	A	0			
Mansfield, Ohio	Cleveland, Ohio	B	2	112	112	
Youngstown, Ohio	Chicago, Ill.	A	2	160	320	
	Pittsburg, Pa.	A	0			

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Cambridge, Ohio	Determination withdrawn					
Zanesville, Ohio	Determination withdrawn					
Enid, Okla.	Oklahoma City, Okla.	B	1	72	72	
	or, Wichita, Kans.	B	1			
Lawton, Okla.	Dallas/Ft. Worth, Tex.	A	0	160	320	
	Oklahoma City, Okla.	A	0			
Ft. Sill, Okla.	Dallas/Ft. Worth, Tex.	A	0	160	320	
	Oklahoma City, Okla.	A	0			
McAlester, Okla.	Oklahoma City, Okla.	B	1	24	24	
	or, Tulsa, Okla.	B	1			
Ponca City, Okla.	Oklahoma City, Okla.	B	1	24	24	
	or, Tulsa, Okla.	B	1			
Stillwater, Okla.	Oklahoma City, Okla.	B	1	24	24	
	or, Tulsa, Okla.					
Albany, Oreg.	Determination withdrawn					
Corvallis, Oreg.	Determination withdrawn					
Astoria, Oreg.	Portland, Oreg.	M	1	0	0	
Reading, Pa.	Philadelphia, Pa.	A	0	160	320	
Williamsport, Pa.	Pittsburg, Pa.	A	1	160	320	
	Philadelphia, Pa.	A	0			
Florence, S.C.	Atlanta, Ga.	A	2	160	320	
	Charlotte, N.C.	A	0			

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Greenville, S.C.	Atlanta, Ga.	A	1	160	320	
	Charlotte, N.C.	A	0			
Spartanburg, S.C.	Atlanta, Ga.	A	1	160	320	
	Charlotte, N.C.	A	0			
Myrtle Beach, S.C.	Atlanta, Ga.	A	2	160	320	
	Charlotte, N.C.	A	1			
Aberdeen, S. Dak.	Minneapolis/St. Paul, Minn.	A	1	160	320	
	Sioux Falls, Minn.	A	1			
Brookings, S. Dak.	Sioux City, Iowa or, Minneapolis/St. Paul, Minn.	B	0	38	38	
		B	1			
Huron, S. Dak.	Sioux City, Iowa or, Minneapolis/St. Paul, Minn.	B	1	88	88	
		B	2			
Mitchell, S. Dak.	Sioux City, Iowa or, Minneapolis,/St. Paul, Minn.	B	0	56	56	
		B	2			
Pierre, S. Dak.	Denver, Colo.	A	2	160	320	
	Sioux City, Iowa	A	1			
	or, Denver, Colo.	A	2	160	320	
	Minneapolis/St. Paul, Minn. or, Minneapolis/St. Paul, Minn.	A	2			
		A	2	160	320	
	Rapid City, S. Dak.	A	0			
Watertown, S. Dak.	Minneapolis/St. Paul, Minn.	B	1	160	320	
	Rapid City, S. Dak.	B	2			

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Yanton, S. Dak.	Omaha, Nebr.	B	1	70	70	
	or, Sioux Falls, S. Dak.	B	0			
Clarksville, Tenn.	Nashville, Tenn.	B	0	24	24	
Ft. Campbell, Tenn.	Nashville, Tenn.	B	0	24	24	
Hopkinsville, Tenn.	Nashville, Tenn.	B	0	54	54	
Jackson, Tenn.	Memphis, Tenn.	B	0	144	144	
Abilene, Tex.	Dallas/Ft. Worth, Tex.	A	0	160	320	
Beaumont, Tex.	Houston, Tex.	A	0	160	320	
Ft. Arthur, Tex.	Houston, Tex.	A	0	160	320	
Brownsville, Tex.	Dallas/Ft. Worth, Tex.	B	0	48	48	
	or, Houston, Tex.	A	1			
Brownwood, Tex.	Dallas/Ft. Worth, Tex.	A	1	160	320	
Harlingen, Tex.	Houston, Tex.	A	0	160	320	
Seaside, Oreg.	Portland, Oreg.	M	1	0	0	
Bend, Oreg.	Portland, Oreg.	D	0			
	Eugene, Oreg.	D	0	160	320	
	or, Medford, Oreg.	D	0			
	or, San Francisco/ Oakland, Calif.	D	2			
Redmond, Oreg.	Portland, Oreg.	D	0			
	Eugene, Oreg.	D	0	160	320	
	or, Medford, Oreg.	D	0			
	or, San Francisco/ Oakland, Calif.	D	2			

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EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Klamath Falls, Oreg.	Portland, Oreg.	D	1	160	320	
	San Francisco/Oakland, Calif.	D	2			
Medford, Oreg.	Portland, Oreg.	A	1	160	320	
	San Francisco/Oakland, Calif.	A	2			
North Bend, Oreg.	Portland, Oreg.	B	1			
	Eugene, Oreg.	B	0	160	320	
	or, Medford, Oreg.	B	0			
	or, San Francisco/ Oakland, Calif.	B	2			
Coos Bay, Oreg.	Portland, Oreg.	B	1			
	Eugene, Oreg.	B	0	160	320	
	or, Medford, Oreg.	B	0			
	or, San Francisco/ Oakland, Calif.	B	2			
Pendleton, Oreg.	Portland, Oreg.	B	1			
	Boise, Idaho	D	1	160	320	
	Salt Lake City, Utah	D	2			
Salem, Oreg.	Portland, Oreg.	B	0			
	or, Eugene, Oreg.	B	0	76	76	
	or, San Francisco/ Oakland, Calif.	B	2			
Altoona, Pa.	Pittsburg, Pa.	A	0	160	320	
Bradford, Pa.	Pittsburg, Pa.	A	0	160	320	
Clearfield, Pa.	Pittsburg, Pa.	A	1	84	168	
Philipsburg, Pa.	Pittsburg, Pa.	A	1	84	168	

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Bellefonte, Pa.	Pittsburg, Pa.	A	1	84	168	
State College, Pa.	Pittsburg, Pa.	A	1	84	168	
Dubois, Pa.	Pittsburg, Pa.	A	0	160	320	
Erie, Pa.	Pittsburg, Pa.	A	0	160	320	
Hazelton, Pa.	Determination withdrawn					
Johnstown, Pa.	Pittsburg, Pa.	A	0	160	320	
Lancaster, Pa.	Philadelphia, Pa.	A	0	160	320	
Oil City, Pa.	Pittsburg, Pa.	B	0	136	136	
Franklin, Pa.	Pittsburg, Pa.	B	0	136	136	
San Beniton, Tex.	Houston, Tex.	A	0	160	320	
College Station, Tex.	Dallas/Ft. Worth, Tex.	B	1	160	160	
	Houston, Tex.	B	0			
Bryan, Tex.	Dallas/Ft. Worth, Tex.	B	1	160	160	
	Houston, Tex.	B	0			
Laredo, Tex.	San Antonio, Tex.	A	0	160	320	
Kilgore, Tex.	Dallas/Ft. Worth, Tex.	A	1	160	320	
Longview, Tex.	Dallas/Ft. Worth, Tex.	A	1	160	320	

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Gladewater, Tex.	Dallas/Ft. Worth, Tex.	A	1	160	320	
Mission, Tex.	Houston, Tex.	A	1	160	320	
McAllen, Tex.	Houston, Tex.	A	1	160	320	
Edinburg, Tex.	Houston, Tex.	A	1	160	320	
Paris, Tex.	Dallas/Ft. Worth, Tex.	B	0	32	32	
San Angelo, Tex.	Dallas/Ft. Worth, Tex.	A	1	160	320	
Temple, Tex.	Dallas/Ft. Worth, Tex.	A	0	132	264	
Tyler, Tex.	Dallas/Ft. Worth, Tex.	A	0	132	264	
Victoria, Tex.	Houston, Tex.	B	0	160	160	
Waco, Tex.	Dallas/Ft. Worth, Tex.	A	0	160	320	
Wichita Falls, Tex.	Dallas/Ft. Worth, Tex.	A	0	160	320	
Cedar City, Utah	Salt Lake City, Utah	B	1	72	72	
	Las Vegas, Nev.	B	1			
Moab, Utah	Salt Lake City, Utah	B	1	16	16	
Vernal, Utah	Salt Lake City, Utah	B	0	54	54	
Montpelier, Vt.	Boston, Mass.	B	1	88	88	
Barre, Vt.	Boston, Mass.	B	1	88	88	
Newport, Utah	Determination withdrawn					
Rutland, Utah	Boston, Mass.	B	1	60	60	
	or, New York City, N.Y.	B	1			

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Charlottes-ville, Va.	Washington, D.C.	A	0	160	320	
	Roanoke, Va.	A	0			
New Port News, Va.	Washington, D.C.	A	0	160	320	
Roanoke, Va.	Washington, D.C.	A	1	160	320	
Staunton, Va.	Washington, D.C.	A	1	160	320	
Ephrata, Wash.	Seattle, Wash.	B	1	20	20	
Moses Lake, Wash.	Seattle, Wash.	B	1	20	20	
Pasco, Wash.	Seattle, Wash.	A	1	160	320	
	Portland, Oreg.	A	0			
Kennewick, Wash.	Seattle, Wash.	A	1			
	Portland, Oreg.	A	0			
Richland, Wash.	Seattle, Wash.	A	1	160	320	
	Portland, Oreg.	A	0			
Pullman, Wash.	Seattle, Wash.	A	2	160	320	
	Spokane, Wash.	A	0			
Moscow, Idaho	Seattle, Wash.	A	2	160	320	
	Spokane, Wash.	A	0			
Walla Walla, Wash.	Seattle, Wash.	A	1	160	320	
	Portland, Oreg.					
Wenatchef, Wash.	Seattle, Wash.	B	0	108	108	
Yakima, Wash.	Seattle, Wash.	A	0	160	320	
	Portland, Oreg.	A	0			
Beckley, W. Va.	Cincinnatti, Ohio	B	1			
	Pittsburg, Pa.	B	1	160	160	
	Greensboro, N.C.	B	0			
	Roanoke, Va.	B	0			

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Clarksburg, W. Va.	Pittsburg, Pa.	A	0	160	320	
	Washington, D.C.	A	1			
Fairmont, W. Va.	Pittsburg, Pa.	A	0	160	320	
	Washington, D.C.	A	1			
Elkins, W. Va.	Pittsburg, Pa.	C	1	44	44	
	Washington, D.C.	C	1			
Greenbrier, W. Va.	Roanoke, Va.	B	0			
	Atlanta, Ga.	B	2	160	160	
	or, Washington, D.C.	B	1			
Huntington, W. Va.	No determination required					
Morgantown, W. Va.	Pittsburg, Pa.	A	0	160	320	
	Washington, D.C.	A	0			
Parkersburg, W. Va.	Pittsburg, Pa.	A	0	160	320	
Princeton, W. Va.	Pittsburg, Pa.	D	1			
	Roanoke, Va.	B	0	160	160	
	or, Greensboro, N.C.	B	0			
Bluefield, Wash.	Pittsburg, Pa.	D	1			
	Roanoke, Va.	B	0	160	160	
	or, Greensboro, N.C.	A	1	160	320	
Appleton, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	1			
Beloit, Wis.	Chicago, Ill.	B	0	92	92	
Jamesville, Wis.	Chicago, Ill.	B	0	92	92	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Eau Claire, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	0			
Green Bay, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	1			
Clintonville, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	1			
La Crosse, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	0			
Manitowoc, Wis.	Chicago, Ill.	B	1	58	58	
Oshkosh, Wis.	Chicago, Ill.	A	1	160	320	
Rhinelander, Wis.	Chicago, Ill.	A	2	160	320	
Land O Lakes, Wis.	Chicago, Ill.	A	2	160	320	
Wausau, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	1	160	320	
Stevens Point, Wis.	Chicago, Ill.	A	1	160	320	
	Minneapolis/St. Paul, Minn.	A	1			
Wisconsin Rapids, Wis.	Chicago, Ill.	K	1	28	0	
Cheyenne, Wyo.	Denver, Colo.	A	0	160	320	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

EAS Points	Designated Hubs	Freq. Code (1)	No. Stops	GAS (2) Weekday	GAS (2) Weekend	S. (3)
Jackson, Wyo.	Denver, Colo. Salt Lake City, Utah	A A	2 1	160	320	S
Jackson, Wyo.	Denver, Colo. Salt Lake City, Utah	E E	2 1	160	320	W
Laramie, Wyo.	Denver, Colo.	A	1	160	320	
Lovell, Wyo.	Denver, Colo.	A	2	152	304	
Powell, Wyo.	Denver, Colo.	A	2	152	304	
Cody, Wyo.	Denver, Colo.	A	2	152	304	
Riverton, Wyo.	Denver, Colo.	A	2	160	320	
Landa, Wyo.	Denver, Colo.	A	2	160	320	
Rock Springs, Wyo.	Denver, Colo.	A	2	160	320	
Sheridan, Wyo.	Denver, Colo.	B	1	160	160	
Worland, Wyo.	Denver, Colo.	B	2	72	72	

Notes: (1) Frequency code is summarized in Attachment I.

(2) GAS refer to Guaranteed Available Seats to all the designated hubs per weekday and by weekend total.

(3) S. indicates applicable seasons.

Attachment I

Code	Explanation Of Frequency Codes
(A)	Two daily round trips.
(B)	Two weekday round trips, total of two round trips on weekends.
(C)	One weekday round trip, total of one round trip on weekends.
(D)	Two weekday round trips, total of three round trips on weekends.
(E)	One weekday round trip and two round trips on Saturday and Sunday during off season (applicable only if aircraft having 50 or more seats are used in the case of Jackson, Wyoming).
(F)	One daily round trip unless service is with small equipment, in which case two daily round trips are required.
(G)	One daily round trip.
(H)	One daily round trip; no weekend service.
(I)	Two round trips Sunday through Friday; no Saturday service.
(J)	Two weekend round trips to any hub including New York; no weekend service.
(K)	Two daily round trips; no weekend service.
(L)	Two weekend round trips, three round trips on Saturday, and one round trip on Sunday.
(M)	Two weekday round trips; total of one weekend round trip.
(N)	Minimum weekly service requirements, eight round-trip flights to each hub (two per day) with service required only four days per week.

Appendix E

DISCRIMINATION AND CLASSIFICATION

I. Introduction

The objective of discrimination and classification is to assign an object into one of several possible groups on the basis of its observed characteristics. To do so, it is necessary to first find a function mapping objects to an index set consisting of group identifiers. The term discrimination refers to the process of arriving at classification rules from samples of classified objects, whereas the term classification refers to the application of the rules to new objects of an unknown group. Maurice Kendall makes another distinction: discrimination is when the number of possible groups is known in advance; classification is when the number of possible groups is not known in advance, but must be determined from the data.

Given two populations P_1 and P_2, the task is to decide whether an object belongs to P_1 or P_2 on the basis of characteristic measures derived from a k-component vector of variables. Table 1 gives a list of examples where such a problem could arise.

Table 1

Characteristic Measurements	Populations P_1 and P_2
1) Price of car, down payment, income, length of loan, previous defaults, whether employed or not, history of alcoholism.	Good and bad auto loan risks.
2) Air passenger demand, size of population, distance to the nearest next hub, unit economy fare, unit lowest possible fare, unit fare differences, the level of service, number of carriers operating in the region.	Communities with subsidized air service and communities without subsidized air service.
3) Distance to the nearest small hub, distance to the nearest medium hub, distance to the nearest large hub, population, buying power, value added by manufacturing.	Non-hubs experiencing improved versus reduced level of air service, five years after deregulation.

II. Test of Existence of Differences in Groups

Table 2 depicts the data on two characteristics of each object, Group I (representing population P_1) consists of seven objects, while Group II (representing population P_2) comprises five objects. In the present case, these two characteristics can be described in the variables summarizing the number of passengers and the size of population, (say X_1 and X_2, respectively.) For simplicity, it is further assumed that the probabilities of occurrence in Group I and in Group II are

equal. To test the significance of the null hypothesis of equality of means, the following analysis applies.

Table 2

MEASUREMENTS OF TWO VARIABLES ON EACH OBJECT

Group I (Subsidized Points)		Group II (Non-Subsidized Points)		Group Sizes
Size of Population in 000's (X_{1i})	Annual Passenger Enplanement in 000's (X_{2i})	Size of Population in 000's (X_{1i})	Annual Passenger Enplanement in 000's (X_{2i})	$n_1=7$ $n_2=5$ $n_1+n_2-2=10$
19	9	16	12	
17	8	19	15	
18	8	15	9	Difference between group means
20	12	16	13	
15	6	14	11	
18	7			
19	13			
Total 126	63	80	60	$d_1=\bar{X}_{11}-\bar{X}_{12}=2$
Mean 18	9	16	12	$d_2=\bar{X}_{21}-\bar{X}_{22}=-3$
Sum of squares		Sum of squares		Pooled within group
16	40	14	20	$X_1X_1=16+14=30$ $X_2X_2=40+20=60$
Sum of products 20		14		$X_1X_2=20+14=34$

$$S_1^2=\frac{X_1X_1}{N-2}=\frac{30}{10}=3\ ,$$

$$S_2^2=\frac{X_2X_2}{N-2}=\frac{60}{10}=6\ ,$$

$$S_{12}=\frac{X_1X_2}{N-2}=\frac{34}{10}=3.4\ .$$

a) Univariate Analysis

Some discrimination and classification problems can be solved through univariate analysis, although this approach is rarely used. For example, it may be possible to determine a person's sex merely from facial characteristics or nationality from an accent. The null hypothesis is that the same mean would apply to all of the population. In the present case, the null hypothesis can be written as; $\bar{X}_{11} - \bar{X}_{12} = 0$ or $\bar{X}_{21} - \bar{X}_{22} = 0$, where ($\bar{X}_{11}$ and $\bar{X}_{21}$) and ($\bar{X}_{12}$ and $\bar{X}_{22}$) are the mean values of Groups I and II respectively.

Let d be the difference between two sample means. For example, if the variable X_{1i} is considered, then $d_1 = \bar{X}_{11} - \bar{X}_{12}$. Let S_1^2 be the pooled estimate of variance from the two groups, that is,

$$S_1^2 = \frac{ssqw}{n_1 + n_2 - 2}$$

where *ssqw* is the total within-group sum of squares which can be expressed as either,

$$\sum_{i=1}^{7} (X_{1i} - \bar{X}_{11})^2 \text{ or } \sum_{i=8}^{12} (X_{1i} - \bar{X}_{12})^2.$$

A standarized distance between two sample means can be written as,

$$D_1 = \frac{d_1}{S_1} = \frac{\bar{X}_{11} - \bar{X}_{12}}{S_1}.$$

The square of the distance is then,

$$D_l^2 = \frac{d_l^2}{S_l^2}.$$

With the distance so defined, it is possible to derive its relationship with student's t as,

$$t^2 = \frac{D_l^2}{\frac{1}{n_1} + \frac{1}{n_2}} = \frac{n_1 n_2}{n_1 + n_2} \cdot D_l^2.$$

The relationship between t^2 and the variance ratio F is generally,

$$F = \frac{N-k-1}{(N-2)\,k} \cdot t^2$$

where k is the number of variables under study. For a single variable case, $k=1$, $N=n_1+n_2$ which is the total number of objects. It should be noted that when $k=1$, the above formula reduces to $F=t^2$. In other words, in cases where only one measurement is examined in isolation on whether the two groups have the same mean, the F value and the student's t^2 are the same. To illustrate how the null hypothesis of the equality of two group means can be tested by looking at one measurement only, an example is used. The example summarizes the derivation of the F value using only one measurement at a time.

Applying the data contained in Table 2, the significance of the difference between the sample means of subsidized and

non-subsidized groups can be tested using either the population measurement or the passenger demand measurement. It can be arrived at;

$$F = t^2 = \frac{n_1 n_2}{N} \cdot \frac{d_1^2}{S_1^2} = \frac{7 \times 5}{12} \cdot \frac{4}{3} = 3.889 \text{ , for population measurement;}$$

or

$$F = t^2 = \frac{n_1 n_2}{N} \cdot \frac{d_2^2}{S_2^2} = \frac{7 \times 5}{12} \cdot \frac{9}{6} = 4.375 \text{ , for passenger demand variable.}$$

The degree of freedom for the numerator and the denominator is 1 and 10 respectively (say (1, 10)). The F value at 5% significant level for (1, 10) degree of freedom is 4.96. Therefore, based on the univariate analysis, the null hypothesis that the means of subsidized and non-subsidized groups are the same can not be rejected.

b) A Multivariate Analysis

The purpose of multivariate analysis is to see whether the two group means differ in the event that all variables are considered at the same time. That is to say, each object is transformed by having a number of measurements taken on it and each measurement provides one variable in a multidimensional space. The statistical techniques would therefore deal with the vectors or points representing objects in this multidimensional space. To conduct a multivariate analysis, the sum of products

(*sqt*) of each pair of variables within the groups is needed. Again, using the data contained in Table 2, the square distance (Mahalanobis's D^2) between the two samples considering both population and demand variables is defined as,

$$D^2 = (d)'(S^2)^{-1}(d)$$

$$= (d_1 \; d_2)\begin{pmatrix} S_1^2 & S_{12} \\ S_{12} & S_2^2 \end{pmatrix}^{-1}\begin{pmatrix} d_1 \\ d_2 \end{pmatrix}$$

where $\begin{pmatrix} S_1^2 & S_{12} \\ S_{12} & S_2^2 \end{pmatrix}$ is the covariance matrix.

Let the determinant of the covariance matrix be Δ, that is,

$$\Delta = \begin{vmatrix} S_1^2 & S_{12} \\ S_{12} & S_2^2 \end{vmatrix} = S_1^2 S_2^2 - (S_{12})^2.$$

The inverse of the covariance matrix can be expressed as,

$$\begin{vmatrix} S_1^2 & S_{12} \\ S_{12} & S_2^2 \end{vmatrix}^{-1} = \frac{1}{\Delta} \cdot \begin{vmatrix} S_2^2 & -S_{12} \\ -S_{12} & S_1^2 \end{vmatrix}.$$

Hence $$D^2 = (d_1 \; d_2)\begin{pmatrix} S_2^2 & -S_{12} \\ -S_{12} & S_1^2 \end{pmatrix}\begin{pmatrix} d_1 \\ d_2 \end{pmatrix} \cdot \frac{1}{\Delta}$$

$$= \frac{1}{\Delta}\left(S_2^2 d_1^2 - 2S_{12} d_1 d_2 + S_1^2 d_2^2\right).$$

Applying the figures in Table 2, it is possible to calculate the Mahalanobis's distance as,

$$D^2 = \frac{1}{6.44}\left[6(2)^2 - 2(3.4)(2)(-3) + 3(-3)^2\right| = 14.254658$$

Once D^2 is determined, the rest of the calculation follows the univariate procedure. Thus, analogously to the one variable case, Hotelling's T^2 which is a generalization of student's t^2 can be written as,

$$T = \frac{n_1 n_2}{n_1 + n_2} \cdot D^2 = \frac{7x5}{12} \times 14.254658$$

$$= 41.576$$

with $k=2$, the F statistic is,

$$F = \frac{N-k-1}{(N-2)k} \cdot T^2 = \frac{9}{10x2}(41.576) = 18.71 .$$

The degree of freedom is 2 for the numerator and 9 for the denominator. The F value at 1% significant level with the said degree of freedom is 8.02. Thus, based on the multivariate analysis, it can be concluded that there is a significant difference between the two group means.

III. Discriminant Function

From the analysis of the data outlined in Table 2, it was concluded that neither population, nor passenger demand on its own can be used to establish that objects in Group I are significantly different from those in Group II. Yet, when both population and passenger demand are considered at the same time, the subsidized and non-subsidized groups differ quite

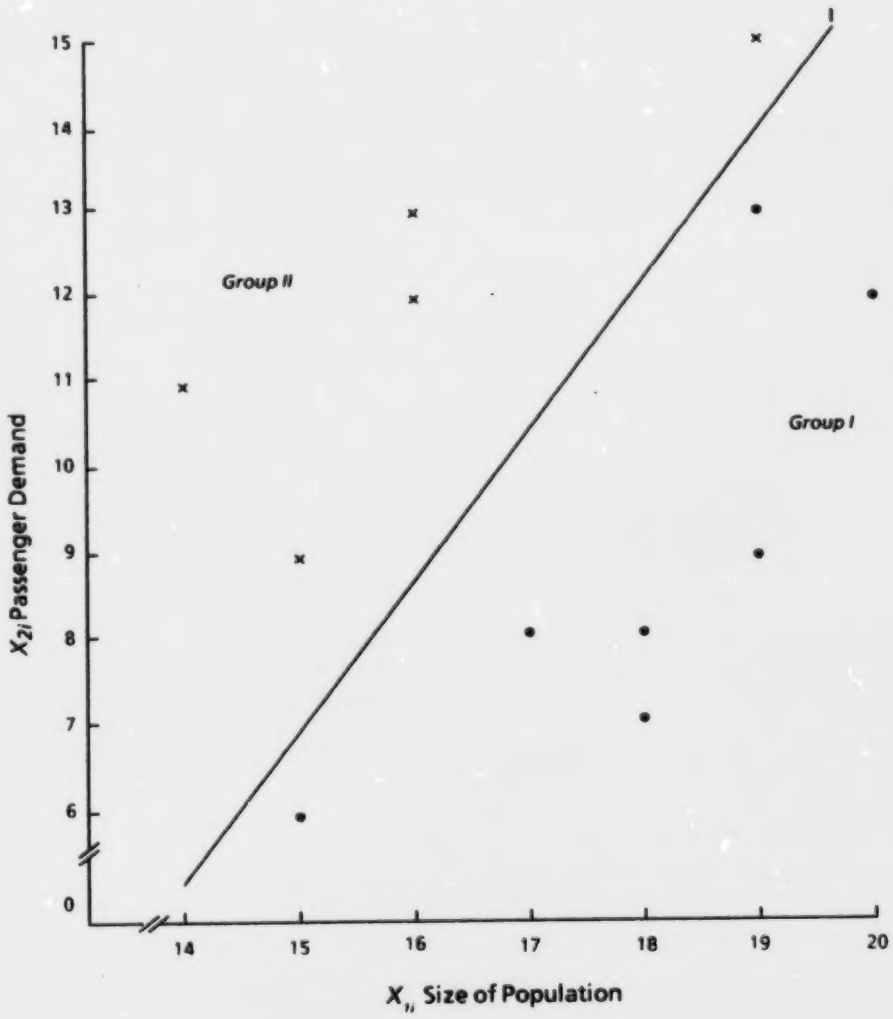
strikingly. This can be explained through a review of Figure 1 which is the scatter diagram of the seven points in Group I and the five points in Group II on the X_1X_2 plane. When the X_1 value alone is considered, that is, the projections of these points on the horizontal axis are looked at, it can be seen that the two groups of points overlap to a very large extent. Similarly, when the X_2 values alone (on the vertical axis) are looked at, it can be seen that they also overlap considerably. The points, plotted on a X_1X_2 plane (according to their X_1 and X_2 values), clearly fall into two groups. It is apparent that a discriminant function measured by line I can be established so that the space is divided into two regions; one for objects falling into Group I and the other for objects falling into Group II. The discriminant rule representing the combination of multiple measurements can be transformed into a linear or quadratic form called a discriminant function.

a) A Linear Discriminant Function

The theory of linear discriminant function was first developed by R.A. Fisher and hence a function taking the form: $L=a'X$ is referred to as Fisher's discriminant function. This discriminant function was derived from the following considerations.

Figure 1

SCATTER DIAGRAM FOR TWO GROUPS OF POINTS (X_1, X_2)
(Data from Table 2)
(in 000's)



• *Denotes subsidized group.*

× *Denotes non-subsidized group.*

Given two normally distributed univariate populations (P_1 and P_2) with means ($\bar{X}_{11}$ and $\bar{X}_{12}$) and a common variance S_1^2, the distance between the means, in units of the standard deviation, S_1, is $(\bar{X}_{11} - \bar{X}_{12})/S_1$. It is clear that an object X_i will be classified in P_1 if it is closer to $\bar{X}_{11}$, or in P_2 if it is closer to $\bar{X}_{12}$. In doing so, there is a risk of misclassification and that risk is smaller if the standardized distance $(\bar{X}_{11} - \bar{X}_{12})/S_1$ is large, because, in that case the two normal curves are further apart and the overlap is smaller. Conversely, in the event that the standardized distance is smaller, there is considerable overlapping of the two areas under the two normal curves, and the chance of misclassification will therefore be increased. In the case of k-variate normal populations, Fisher suggested that the k measurements be combined linearly, in such a manner that the distance, $(\bar{X}_{11} - \bar{X}_{12})/S_1$, would be maximized. Therefore, the k-dimensional classification procedure is reduced to a one-dimensional one, by choosing $a'X$ such that the following distance is maximized with respect to "a":

$$\frac{\text{mean of } a'x \text{ in } P_1 - \text{mean of } a'x \text{ in } P_2}{\text{standard deviation of } a'x} = \frac{a'd}{(a'sa)^{\frac{1}{2}}}.$$

Differentiating the above with respect to "a" and equating the result to zero, we derive,

$$d = \left(\frac{a'd}{a'sa}\right) . sa .$$

Since $\frac{a'd}{(a'sa)^{\frac{1}{2}}}$ is a constant, we can obtain, $a = cS^{-1}d$ where c is a constant.

Having determined "a", it is now possible to arrive at a linear combination of measurements ($L = a'X$) such that differences among groups can be maximized. Such a combination is called a discriminant function because it entails the maximum discriminating power for these groups of objects. Fisher's discriminant function is derived by setting the constant to one. When the constant equals to Mahalanobis's distance, the discriminant function corresponds to the first canonical variate.

Using the example given in Table 2, it is possible to arrive at Fisher's discriminant function as follows,

$$L = a'x$$

$$= \left(S^{-1}d\right)'x$$

$$= d'\left(S^{-1}\right)'x$$

$$= \left(d_1\ d_2\right)\frac{1}{\Delta}\begin{vmatrix} S_2^2 & -S_{12} \\ -S_{12} & S_1^2 \end{vmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

$$= \frac{1}{\Delta}\left(\left(S_2^2 d_1 - S_{12}d_2\right)\left(S_1^2 d_2 - S_{12}d_1\right)\right)\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

$$= \frac{1}{\Delta}\left|\left(S_2^2 d_1 - S_{12}d_2\right)x_1 + \left(S_1^2 d_2 - S_{12}d_1\right)x_2\right|$$

$$= \frac{1}{6.44}\left|(6 \times 2 + 3.4 \times 3)x_1 + (-3 \times 3 - 3.4 \times 2)x_2\right|$$

$$= 3.4472\,x_1 - 2.45342\,x_2$$

Once the linear discriminant function is calculated, an object X can be classified into one of the g populations based on its discriminant score $a'X$. The scores for the sample means are calculated, based on the means of all measurements for each group, and can be expressed as $a'\bar{X}_1$, $a'\bar{X}_2$, etc. Then an object X is assigned to the population whose mean score is closest to $a'X$, that is, allocate X to population (P_i), if,

$$\left| a'x - a'\bar{X}_i \right| < \left| a'x - a'\bar{X}_j \right|, \text{ for all } j = 1 \ldots g, \text{ and } j \neq 1,$$

where

$$\bar{X}_1 = \begin{bmatrix} \bar{X}_{11} \\ \bar{X}_{21} \\ \vdots \\ \bar{X}_{g1} \end{bmatrix} \quad \bar{X}_2 = \begin{bmatrix} \bar{X}_{12} \\ \bar{X}_{21} \\ \vdots \\ \bar{X}_{g2} \end{bmatrix}, \; g \text{ is the number of groups.}$$

In the case of two groups, the discriminant rule becomes,

$$\textit{allocate } x \textit{ to } p_1, \textit{ if } d'S^{-1}\left\{X - \frac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right\} > 0.$$

Otherwise, X would be allocated to P_2.

Table 3 provides the discriminant scores and the corresponding values when applying the discrimant rule based on the data of Table 2.

Table 3
DISCRIMINANT SCORES $L=a_1X_{1i}+a_2X$
WHERE $a_1=3.4472$, $a_2=-2.4534$

Group I			Group II		
Discriminant Scores	Discriminant Values for Rule Application	Classified Information	Discriminant Scores	Discriminant Values for Rule Application	Classified Information
43.4161	10.5745	I	25.7143	-7.1273	II
38.9752	6.1336	I	28.6957	-4.1459	II
42.4223	9.5807	I	29.6273	-3.2143	II
39.5031	6.6615	I	23.2609	-9.5807	II
36.9876	4.1460	I	21.2733	-11.5683	II
44.8758	12.0342	I			
33.6025	0.7609	I			
Mean					
39.9689			25.7143		

In Group I, the discriminant score varies from 33.6 to 44.9, whereas in Group II it varies from 21.3 to 29.6; the difference therefore is quite clear-cut.

b) Unequal Prior Probabilities (A Two Population Case)

In constructing a procedure of classification, the objective is to minimize the probability of misclassification, or, more specifically, to minimize the maximum expected misclassifications. In the case of a two population classification procedure, two kinds of errors might occur: if an object is actually from population P_1 and is classified as coming from population P_2; or if it is from population P_2 and is classified into population P_1. If the cost of the first type of misclassification is $C(2|1)>0$, and the cost of the second type

of misclassification is $C(1|2)>0$, then Table 4 depicts the costs of misclassification.

Table 4

COST OF CORRECT AND INCORRECT CLASSIFICATIONS

Population	Classified into	
	P_1	P_2
P_1	0	$C(2\|1)$
P_2	$C(1\|2)$	0

Table 5 provides the probabilities that an object is correctly or incorrectly classified into one of the two populations, while Table 6 summarizes the probabilities that an object drawn from one population is correctly or incorrectly classified into a population.

Table 5

THE PROBABILITIES OF CORRECTLY OR INCORRECTLY CLASSIFYING AN OBJECT INTO ONE OF THE POPULATIONS

Population	Classified into	
	P_1	P_2
P_1	$f(1\|1,R)=\int_{R1}f_1(x)dx$	$f(2\|1,R)=\int_{R2}f_1(x)dx$
P_2	$f(1\|2,R)=\int_{R1}f_2(x)dx$	$f(2\|2,R)=\int_{R2}f_2(x)dx$

Table 6

THE PROBABILITIES OF DRAWING AN OBJECT FROM ONE POPULATION AND CLASSIFYING IT CORRECTLY OR INCORRECTLY INTO ONE OF THE POPULATIONS

Drawing from Population	Classified into	
	P_1	P_2
P_1	$q_1 xf(1\mid 1,R)$	$q_1 xf(2\mid 1,R)$
P_2	$q_2 xf(1\mid 2,R)$	$q_2 xf(2\mid 2,R)$
Where: Density function of population P_1 and P_2 are $f_1(x)$ and $f_2(x)$, and prior probabilities are q_1 and q_2 (where $q_1+q_2=1$)		

Classification rule:

X space is divided into two regions R_1 and R_2. If an object falls in R_1, it is allocated to P_1. If an object falls into R_2, it is allocated to P_2.

Therefore, the expected costs of misclassification can be written as,

$$C(2\mid 1)\, f(2\mid 1,R)q_1+C(1\mid 2)\, f(1\mid 2,R)q_2$$

$$=C(2\mid 1)\int_{R2} f_1(x)\,dx q_1+C(1\mid 2)\int_{R1} f_2(x)dx q_2$$

$$=\int_{R2}\left[C(2\mid 1)q_1 f_1(x)-C(1\mid 2)\, q_2 f_2(x)\right]dx+C(1\mid 2)q_2\int f_2(X)\,dx.$$

The last term is a positive constant, and therefore the expression as a whole is minimized, if R_2 includes the points X such that,

$$\left|C(2 \mid 1)q_1 f_1(X) - C(1 \mid 2)q_2 f_2(X)\right| < 0 .$$

Therefore, the classification rule is to classify an object X into the region,

$$R_1: \left|C(1 \mid 2)q_1\right| f_1(x) > \left|C(1 \mid 2)q_2 f_2(x)\right|$$

$$R_2: \left|C(2 \mid 1)q_1\right| f_1(x) < \left|C(1 \mid 2)q_2 f_2(x)\right| .$$

Since $C(2 \mid 1)q_1$ and $C(1|2)q_2$ are non-negative constants, the above can be rewritten:

$$R_1: \frac{f_1(X)}{f_2(X)} > \frac{C(1 \mid 2)q_2}{C(2 \mid 1)q_1} \quad \ldots\ldots\ldots (1)$$

$$R_2: \frac{f_1(X)}{f_2(X)} < \frac{C(1 \mid 2)q_2}{C(2 \mid 1)q_1} \quad \ldots\ldots\ldots (2)$$

If it is assumed that $f_1(x)$ and $f_2(x)$ are each multivariate normal with different mean vectors $\bar{X}_1$ and $\bar{X}_2$ but with the same covariance matrix(s). The ratio of the densities can be expressed:

$$\frac{f_1(X)}{f_2(X)} = \frac{exp\left[\tfrac{1}{2}\left(X-\bar{X}_1\right)' S^{-1}\left(X-\bar{X}_1\right)\right]}{exp\left[\tfrac{1}{2}\left(X-\bar{X}_2\right)' S^{-1}\left(X-\bar{X}_2\right)\right]}$$

$$= exp\left[X'S^{-1}\left(\bar{X}_1-\bar{X}_2\right) - \tfrac{1}{2}\left(\bar{X}_1+\bar{X}_2\right)' S^{-1}\left(\bar{X}_1-\bar{X}_2\right)\right]$$

$$d = \bar{X}_1 - \bar{X}_2$$

$$= exp\left\{\left[X' - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)'\right] S^{-1} d\right\}$$

$$= exp\left\{d' S^{-1}\left[X - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right]\right\}.$$

Therefore, equation 1 and 2 can be rewritten,

$$R_1: d' S^{-1}\left[X - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right] > \ln C\left(\frac{q_2}{q_1}\right)$$

$$R_2: d' S^{-1}\left[X - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right] < \ln C\left(\frac{q_2}{q_1}\right)$$

where: $C = \dfrac{C(1 \mid 2)}{C(2 \mid 1)}$.

As in most cases, the costs associated with either the first or second type of misclassification are unknown, and it would be reasonable to assume that they are the same. If $C(1 \mid 2) = C(2 \mid 1)$, then $C = 1$ and the classification rule can be written as,

$$R_1: d' S^{-1}\left[X - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right] + \ln \frac{q_1}{q_2} > 0$$

$$R_2: d' S^{-1}\left[X - \tfrac{1}{2}\left(\bar{X}_1 + \bar{X}_2\right)\right] + \ln \frac{q_1}{q_2} < 0.$$

Therefore, in the case of unequal prior probabilities, a constant representing $\ln q_1/q_2$ would be added to the

discriminant function. Figure 2 depicts the discriminant function with equal and unequal prior probabilities using the example outlined in Table 2.

c) The Quadratic Discriminant Function

The linear discriminant function minimizes the overall probability of misclassification on the assumption that the sampling is from multivariate normal populations with known means and with a known, equal group dispersion matrix. In the event that within-group covariance matrices are homogeneous*, the discriminant function can be reduced to a linear form in terms of the pooled covariance matrix. In many applications, the assumption of the equality of k group dispersion matrices is not justified. When population parameters are known and covariance matrices are unequal, the quadratic discriminant function is optimal in minimizing the overall probability of misclassification.

A test criterion for the null hypothesis of the homogeneity of within-group covariance matrices has been established by G.E.P. Box. Should the null hypothesis be rejected, the within-group covariance matrices will be selected to arrive at a quadratic discriminant function.

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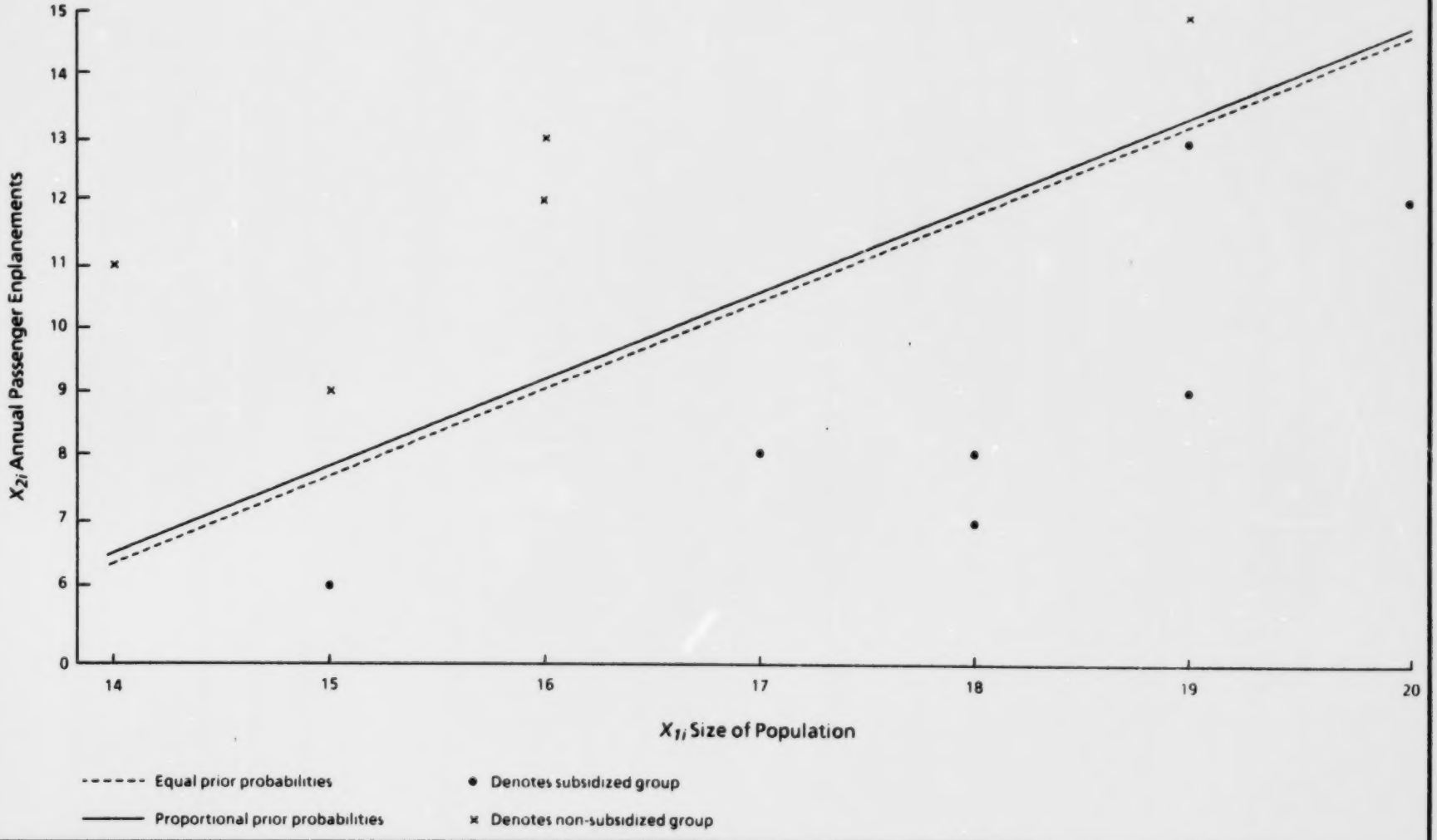
* The formula used to test for homogeneity in the SAS statistical user's guide was referred to as the test for homoscedasticity in the paper published by G.E.P. Box.

Figure 2

LINEAR DISCRIMINANT FUNCTION WITH EQUAL AND UNEQUAL PRIOR PROBABILITIES



The quadratic discriminant function is determined by a measure of generalized least square distance, $D_i^2(x)$, which can be expressed as,

$$D_i^2(X)=(X-\bar{X}_i)'S_i^{-1}(X-\bar{X}_i)+ln\left|S_i\right|-2\ln q_i$$

where: $ln\,|Si|$ is the natural logarithm of the determinant of the *ith* within-group covariance matrix.

The quadratic discriminant function classifies an object X into population P_j, if $D_j^2(X)$ is the minimum of the g distances $D_i^2(X)$. For instance, in the case of a two-population classification application, the quadratic discriminant function $Q(X)$ can be reduced to,

$$Q(X)=D_2^2(X)-D_1^2(X)$$

$$=(X-\bar{X}_2)'S_2^{-1}(X_1-\bar{X}_2)-(X-\bar{X}_1)'S_i^{-1}(X-\bar{X}_1)+ln\left(\frac{\left|S_2\right|}{\left|S_1\right|}\right)+2\ln\frac{q_1}{q_2}$$

An object X is classified into P_2 if $Q(X)$, the quadratic discriminant function, is less than zero.

d) The Nonparametric Nearest-Neighbour Classification Rule

In the event that the classes have radically non-normal distributions, one should use the nonparametric nearest neighbor discriminant analysis. An object is classified into groups in accordance with either the nearest neighbor rule or the *gth*

nearest-neighbor rule. The distance can be measured by either Mahalanobis distance based on the total covariance matrix or Euclidean distance. This nonparametric method could not be applied in the present analysis due to the lack of an accurate computer program.

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